

**2009 ANNUAL COMPREHENSIVE REPORT  
OF GROUND AND SURFACE WATER QUALITY  
TRONOX SODA SPRINGS, IDAHO FACILITY**

February 26, 2010

**Prepared by:**



GLOBAL ENVIRONMENTAL TECHNOLOGIES L.L.C.



GLOBAL ENVIRONMENTAL TECHNOLOGIES L.L.C.

February 26, 2010  
TRONOX  
P.O. Box 478  
Soda Springs, Idaho 83276

Attn: Mr. Boyd Schvaneveldt  
Plant Manager

**RE: TRANSMITTAL: REMEDIAL ACTION 2009 ANNUAL COMPREHENSIVE  
REPORT OF GROUND AND SURFACE WATER QUALITY TRONOX SODA  
SPRINGS, IDAHO FACILITY**

Dear Mr. Schvaneveldt:

Enclosed please find transmitted the Remedial Action 2009 Annual Comprehensive Report of Ground and Surface Water Quality for the Tronox Soda Springs, Idaho Facility. This document consist of: 1) an evaluation of the most currently available (May and October 2009) ground water quality distribution at on- and off-site locations for selected parameters; 2) an evaluation of ground and surface water quality changes with time; 3) projected decay trends for selected COC and wells for the period between 1997 and 2009 and a second set spanning 2004 through 2009, and; 4) conclusions regarding the effects to ground water from remedial actions and reclamation efforts to date. We have included the most recently available validated data from the Evergreen site that is located downgradient of the Tronox plant site.

We appreciate the opportunity to work with you on this project. If you have any questions regarding this transmittal, please contact us.

Very truly yours,  
Global Environmental Technologies, LLC

John S. Brown, P.G.  
Principal/Owner

Attachments: Remedial Action 2009 Annual Comprehensive Report of Ground and Surface Water Quality

xc:John Hatmaker (Tronox)  
Roy Widmann (Tronox)  
Matt Paque – (Tronox)  
Bill Ryan — EPA Region X – (4 copies)  
Doug Tanner — IDEQ Pocatello  
Dean Nygard — IDEQ Boise

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## 1.0 INTRODUCTION

### 1.1 Ground Water Monitoring Program

Tronox (formerly Kerr-McGee Chemical LLC) monitors water levels and water quality in both on- and off-site wells and selected springs on a semiannual basis. Data reports are presented to the EPA and IDEQ on a semiannual basis. Validation reports that included the 2009 data incorporated into the Remedial Design/Remedial Action (RD/RA) database were issued to EPA on November 29, 2009 and on February 9, 2010. The database is not included in this report, and the reader should refer to the data contained within the validation reports in conjunction with this document. The RD/RA database contains all sample analytical data supplied by the laboratory following the completion of the Remedial Investigation/Feasibility Study (RI/FS) study, and was prepared at the request of Region 10 EPA on September 23, 1997.

Monitor wells were installed at strategic locations to monitor specific surface water impoundments, aquifer units, downgradient off-site locations, and the Tronox facility as a whole. Locations of on- and off-site well placements and screen location depths are shown in Table 1-1. These data are also presented in previous technical memoranda and work plans (Dames & Moore, 1991 a, b and 1992).

Location of the Tronox site and property owned by Tronox is shown on Figure 1-1. Locations of all monitoring wells installed during the remedial investigation (RI) are shown on Figure 1-2. Figure 1-2 also presents measured water level elevations and ground water gradients in May 2009.

Thirteen of the 18 RI/FS wells are designated "shallow" wells with total depths of 45 to 73 feet. Four wells are designated "intermediate-depth" wells with total depths of 100 to 173 feet. One well (KM-19) is completed on-site to a total depth of 230 feet and designated a "deep" well.

The shallow wells are completed with 10 feet of well screen that is set in the uppermost-defined basalt flow or interflow zone. Shallow wells were completed within the first occurrence of ground water that was encountered while drilling. On-site shallow wells include wells KM-1, KM-2, KM-3, KM-4, KM-5, KM-6, KM-7, KM-8, KM-9, and KM-13. Off-site shallow wells include KM-15, KM-16, and KM-17.

The intermediate-depth wells are completed with 20 feet of well screen that is set in a deeper basalt flow identified across the site through geophysical interpretation. On-site intermediate depth wells include KM-10, KM-11, and KM-12. The off-site intermediate-depth well is designated KM-18.

## 1.2 Remedial Action Completion

A complete discussion of the Remedial Action Completion activities is described in the Draft Remedial Action Completion Report Revision I (GET, 1999), and the Draft Remedial Action Completion Report for Calcine Capping, 2000 through 2001 (GET, 2003). Remedial Action for the Tronox vanadium facility addressed the selected site remedy from the Record of Decision (ROD, September 1995) and subsequent amendment to the ROD (July 2000). The Remedial Action for the vanadium plant included:

- Elimination of uncontrolled liquid discharges from the site;
- Landfilling solids from the scrubber and S-X ponds at an on-site landfill;
- In-place capping of the wind-blown calcine, roaster reject, reject fertilizer, and active calcine tailings during 2000 and 2001;
- Semi-annual ground water monitoring to determine the effectiveness of source control, and;
- Establishment of institutional controls in affected off-site areas to prevent ingestion of ground water for as long as the ground water exceeds the risk-based concentrations (RBC).



### 1.2.1 Liquid Source Elimination

The ROD required Kerr-McGee Chemical to implement Liquid Source Elimination (LSE) to eliminate the uncontrolled releases of process water to ground water. During 1993, the unlined magnesium ammonium phosphate (MAP) ponds were removed from service and covered. This action had an immediate effect on water quality in nearby well KM-5. Three larger unlined ponds at the facility were either eliminated or replaced to accomplish LSE between 1995 and 1997. These three ponds included the roaster scrubber pond, S-X raffinate pond, and the calcine pond (s). Elimination of these ponds also had an effect on ground water quality

#### 1.2.1.1 Scrubber Pond

Wet scrubbers controlled air emissions from the vanadium roasters since the plant began operating in 1963. The solids collected in the scrubbers and in the discharge water were pumped to various scrubber water ponds. This management practice resulted in an uncontrolled release of the process water to ground water, and left the solids from the process impounded in each pond. The scrubber sediments from the former pond on the east side of the facility were impounded in the on-site landfill, constructed during 1997.

The wet scrubbers were replaced by a baghouse system on each roaster in 1997. The baghouse collected particulate emissions without the use of water. Solids collected in the baghouse were impounded with the calcine. The result of the installation of the baghouse system was the elimination of the scrubber pond. This allowed for the excavation and placement of the roaster scrubber solids in the landfill and the closure and reclamation of the roaster scrubber pond.

The vanadium plant and supporting baghouse facilities were dismantled between October 2001 and February 2002. The footprint of the vanadium plant was covered

with limestone fines and recontoured to provide positive drainage away from the site of the former facility.

#### 1.2.1.2 S-X Pond

Tronox constructed 20 acres of double-lined ponds in 1995 and 1997 to contain the S-X raffinate stream. Use of the unlined S-X pond was discontinued by 1996 and the sediment was pushed into a pile when the bottom was dry. The S-X pond sediments were excavated from the pond and impounded in the on-site constructed landfill in 1997. The 5-acre ponds were reclaimed in 2004, while the 10-acre pond still remains at the site and contains the plant wastes excavated from the two storm water and the two 5-acre ponds.

#### 1.2.1.3 Calcine Pond

Historically, calcine was deposited in the impoundment area by mixing the solids from the vanadium leaching process with water and pumping the slurry to the calcine impoundment. The water used in this operation infiltrated through unlined calcine ponds. Tronox installed a mechanical dewatering system to separate the water and the calcine in 1997, eliminating the pond. No calcine was produced following closure of the plant in 1999 and the calcine impoundment site was capped with a synthetic liner in 2001.

### 1.3 LSE Completion

The S-X pond was taken out of service during 1996. During November 1996, the S-X pond sediments and underlying soils were dozed to the south end of the pond and covered with plastic. This action allowed an extended period for the S-X solids to dry and consolidate.

The scrubber pond was taken out of service in April 1997 and was drained prior to the sediment thickness investigation. The scrubber solids were worked into windrows and piles in the scrubber pond basin to accelerate drying.

Tronox excavated and transported S-X and scrubber pond sludge to an engineered landfill constructed during September 1997. Prior to compaction in the landfill, the wastes were mixed at a ratio of 3:1 scrubber to S-X solids to achieve optimum moisture for compaction. During the last week of September 1997, the Idaho Department of Environmental Quality (IDEQ) inspected the pond basins and determined that all of the pond solids had been removed from the native soils lining the pond basins. Several feet of clean native soil were placed in the pond basins to support growth of a vegetative cover. The overall site slopes were graded and sloped to promote runoff away from the preexisting pond locations.

Pond reclamation activities occurred during the last week of September and during the first week of October 1997. Following removal of sediment materials from the pond basins and approval of closure from the IDEQ, completeness of sediment removal from pond basins was documented with photographs.

#### 1.4 Ground Water COC

The six contaminants of concern (COC) that were identified in the Risk Assessment (EPA, 1993) include arsenic, manganese, molybdenum, tributyl phosphate, total petroleum hydrocarbons, and vanadium. Table 1-2 presents a range of concentrations for COC at the POC wells, showing both the largest and the most recent (October 2009) concentrations.

## 2.0 SUMMARY OF SITE HYDROGEOLOGY

### 2.1 Site Hydrogeology

Ground water beneath and downgradient from the Tronox site exists within the basalt sequences, the basalt interflow zones, and within limited areas of the alluvium. Ground water also exists within the Tertiary Salt Lake Formation that underlies the basalt. All of the on-site and off-site monitor wells installed as part of the Tronox RI/FS are completed at various depths within the basalts and basalt interflow zones, as shown in Table 1-1. Although ground water occurs in the Salt Lake Formation and within a limited area of the alluvium on-site, the basalts are considered the principal aquifer beneath the Tronox site and the Monsanto site to the west. Monsanto production wells extract ground water from the basalt aquifer.

The hydrogeologic properties of the basalts and interflow zones were characterized during the Kerr-McGee RI/FS, using:

- Geologic, geophysical, hydraulic head, hydraulic gradient, and hydraulic conductivity parameters from the installed wells;
- Hydraulic response data observed in the monitor wells, and;
- Observation and testing data from 14 on-site monitor wells, 4 off-site monitor wells and 5 on-site coreholes.

#### 2.1.1 The Salt Lake Formation

The Tertiary Salt Lake Formation is comprised of tuffaceous sandstones, conglomerates and limestones that yield small amounts of ground water for domestic and stock purposes, and are unpredictable as a water-supply source. The Salt Lake Formation is not considered part of the shallow ground water system. The Salt Lake Formation was investigated on-site in corehole CH-3 from 231 to 250 feet (total depth of corehole CH-3) and was found to consist of fractured quartzite, sandstone, and clay. Packer testing

resulted in a hydraulic conductivity determination of 0.77 ft/day. This result is within, but at the low end of the range of packer-test hydraulic conductivities estimated for the deeper part of the overlying basalt sequence. No wells at the Tronox site are completed within the Salt Lake formation.

### 2.1.2 Alluvium

Seismic refraction studies performed as part of the RI indicated that alluvium is thickest and extends to the greatest depth on the eastern side of the plant facility. Based on geologic data from well KM-2, a small area of thin saturated alluvium overlies the basalt in the eastern part of the Tronox facility where the elevation of the basalt/alluvium contact falls below the elevation of the water table. Well KM-2 is screened across the basalt/alluvium contact. The area of saturated alluvium appears to be limited near the east side of the facility, extending a short distance to the north and south of the capped calcine tailings. The alluvium has not been noted to contain ground water at other locations on the Tronox site.

### 2.1.3 Basalt Aquifer

The basalts and interflow zones of the mid-Pleistocene Blackfoot Lava Field comprise the principal aquifer beneath the Tronox site. All of the on-site Tronox monitor wells, with the exception of well KM-2, are screened exclusively within these basalts and interflow zones. The basalt sequence at the Tronox site, described in the RI is comprised of five identifiable basalt flows (Basalts Nos. Qb<sub>1</sub> through Qb<sub>5</sub>) and associated interflow zones (Interflow Zones Nos. I<sub>1</sub> through I<sub>4</sub>). Two younger basalts (Qb<sub>5a</sub> and Qb<sub>5b</sub>) and associated interflows were identified to the south and west of the site and are believed to have occurred as post-faulting flows. These basalts and interflow zones are believed to be stratigraphically similar to basalt flows identified at the Monsanto Site by Golder (1985 and 1992a). However, the hydrogeologic characteristics of the basalt flows between the two sites appear to be different. Notable differences include:

- Magnitudes of hydraulic conductivities of the basalt flows and interflow zones at the Tronox site are relatively similar based on the results of extensive aquifer testing, whereas basalts and interflow units at the Monsanto site are indicated to differ substantially;
- Local water level elevation and water quality differences exist between adjacent shallow, intermediate-depth and deep wells at Monsanto. Water quality and aquifer test data for Tronox indicate that the entire thickness of saturated basalt is in relatively good vertical hydraulic connection over the area of the Tronox site, and;
- Faults are considered to represent zones of increased transmissivity at the Tronox site, whereas they are interpreted to be barriers to flow at the Monsanto site.

#### 2.1.3.1 Hydraulic Conductivities of the Basalt Aquifer

Primary permeability of unbroken basalt is small. Most ground water in the basalt aquifer is transmitted along secondary features such as joints or fractures. Vertical columnar joints are a common feature observed in basalt exposed to the south and southwest of the site along the trace of the Finch Spring Fault. The presence of intensely fractured or vesicular zones, rubble zones, and/or cinder zones can also greatly increase the ability of basalt to transmit water. Interflow zones are comprised of subaerial deposited materials, including clays, cinderaceous deposits, alluvial sands and gravels, organic debris and weathered and broken basalt. Variations in the ability of interflow zones to transmit water result from changes in the character and thickness of these materials.

Observed hydraulic conductivities estimated from the slug, specific capacity, and pumping tests conducted in the shallow, intermediate-depth, and deep wells include the following:

- Basalts ranged from 8 to 340 ft/day;
- Interflow zones ranged from 90 to more than 200 ft/day.
- Basalts and interflow zones together ranged from 2 to more than 100 ft/day.
- Basalt No. Qb<sub>5</sub> (shallow basalt represented by shallow well screened zones) ranged from about 9 to 340 ft/day.

- Basalt No. Qb<sub>3</sub> (Deeper basalt screened in wells KM-10, KM-11, KM-12, and KM-18) ranged from 8 to almost 100 ft/day.

Hydraulic conductivities estimated for well KM-19 screened in Basalt No. Qb<sub>2</sub> and Interflow Zone No. I<sub>1</sub> ranged from about 15 to almost 70 ft/day. Results are presented in Table 1-1.

Generalizations about hydraulic conductivities observed within the basalt aquifer at the Tronox site include the following:

- The hydraulic conductivities of interflow zones are not significantly greater than those of the basalt flows;
- Hydraulic conductivities of the shallower basalts (Basalt No. Qb<sub>5</sub>) are generally greater but not significantly greater than those of the deeper basalts (Basalt No. Qb<sub>3</sub>);
- A horizontal layer of significantly smaller hydraulic conductivity which could greatly limit or prevent vertical movement of ground water was not identified;
- A continuous horizontal layer of significantly larger hydraulic conductivity along which horizontal ground water flow could be localized was not identified;
- Hydraulic conductivities in the shallow wells on the east side of the plant (KM-1, KM-2, KM-3, and KM-4) range from 90 to 270 ft/day and appear to be greater than hydraulic conductivities in shallow wells on the west side of the plant (KM-5, KM-8, KM-9, and KM-13), which range from 9 to 48 ft/day.

#### 2.1.3.2 Estimated Ground Water Velocities

Horizontal hydraulic gradients within the shallower basalt aquifer vary from 0.01 feet per foot in the eastern part of the site to 0.03 feet per foot in the western part of the site. Effective porosities have been reported for the basalts of the Snake River Plain aquifer of southeastern Idaho to range from about 8 to 10 percent (Robertson, 1974; Lewis and Goldstein, 1982; Isherwood, 1981; Nace et al., 1959). If an effective porosity of 8 percent and range of hydraulic conductivities of 5 to 270 ft/day is used, then a range of estimated ground water particle velocities of 0.6 to 34 ft/day can be calculated for the eastern part of the plant site. The effective porosity of 8 percent and the observed range of hydraulic

conductivities of 9 to 340 ft/day on the western of the site yield a range of estimated ground water particle velocities of 3 to 130 ft/day for the western part of the plant site.

## 2.2 Current Direction and Rate of Ground Water Flow

Ground water flows in response to hydraulic gradients from areas of higher hydraulic head to areas of lower hydraulic head at rates that are proportional to hydraulic conductivity and hydraulic gradient and inversely proportional to effective porosity of the aquifer. Ground water can flow vertically through aquifers or between aquifers in response to vertical hydraulic gradients and horizontally within aquifers in response to horizontal gradients. Ground water in the Shallow Aquifer System generally flows southward from the topographically higher Blackfoot Reservoir (about 12 miles north of the Tronox facility) to seeps and springs along the topographically lower Bear River.

Horizontal hydraulic gradients and ground water flow directions within the shallow basalt units at the site are indicated by water level elevations measured during May 2009 and are contoured on Figure 1-2. Site gradient averaged about 0.02 ft/ft in 2009.

The predominant flow direction beneath the plant site is to the west-southwesterly, as shown on Figure 1-2. The western ground water flow direction beneath the site is caused by pumping from the Monsanto production wells located west of the Tronox site. Ground water levels beneath the east side of the facility suggest a more southerly flow component, with flow beneath the east side of the facility directed towards well KM-3. This subtle change in flow direction may be the result of capping the calcine in 2001. Previous annual evaluations indicated a flatter and more westerly overall flow pattern for this area.

Water level elevations measured during May 2009 in the deeper monitor wells KM-11, KM-12, and KM-18 are also shown on Figure 1-2 but are not contoured. Ground water levels in the deeper wells indicate a pattern of ground water flow that is similar to the pattern observed in the shallow wells.



### 2.3 Site Water Levels and Site Precipitation

Figure 2-1 presents annual rainfall totals for Soda Springs, Idaho between 1990 and 2009, obtained from Tigert Airport in Soda Springs. Annual totals peaked at about 17.5 inches in 1994 and 1997. Annual precipitation rates declined after 1997 to about 11.5 inches in 2001. Annual precipitation rates increased on average between 2001 and 2005, to just over 15 inches on an annual average. Since 2004, only one year (2007) was below the 15 inch annual average

Site ground water level changes over time correlate with variation in the annual average precipitation, rates, although general rises in site water levels lag the precipitation by about three years, based on the observation of the low annual average in 2001 and recovery in water levels in site wells after 2004. Overall, water levels dropped on average 5 to 8 feet between 1997 and October 2001, and then remained at lowered levels in the fall through 2004, as indicated on Figure 2-2. Water levels recovered between 2004 and 2009 as a result of the increased annual average since 2003. A spike in water levels is noted in 2006. Water level data show that levels are seasonal. Water levels are typically higher by about 2 to 3 feet in the spring when compared with the fall water levels.

### **3.0 GROUND WATER SAMPLING**

#### **3.1 Ground Water Point of Compliance**

The Record of Decision (EPA, September 1995) stated that the point of compliance (POC) for the evaluation of the selected remedial actions for ground water will be the boundary of the current active industrial facility, using the existing monitoring wells (EPA, 1995). During the RI, Tronox placed monitor wells at strategic locations to monitor specific impoundments, aquifer units, downgradient off-site locations, and the facility as a whole. Locations of on- and off-site well placements and screen location depths were presented in previous technical memoranda and work plans.

During 2004, Tronox purchased the Hopkins property to the south of the former industrial facility. This property includes the areas containing the monitoring wells KM-15, KM-16, KM-17, and KM-18, that have been designated the “off-site” wells in all previous documents. The off-site designation is continued in this document, referring to wells that are located off of the industrial facility, as established by EPA.

POC wells include wells KM-2, KM-3, KM-5, KM-8, KM-9, KM-11, KM-12, KM-13, and KM-19. EPA requested the addition of wells KM-2, KM-3 and KM-11 to the list in their May 6, 1997 correspondence and Tronox included POC sampling for these wells. Table 3-1 provides the justifications used for sampling of POC wells at the site, and for sampling off-site well and spring locations.

#### **3.2 Ground Water Sampling and Analysis Plan**

A ground and surface water sampling plan was developed for the RD/RA sampling events for on-going semiannual sampling. This plan was finalized and accepted by EPA during May 1997. An additional low-flow sampling plan was developed during September 1997 to incorporate low-flow sampling methods described below.

### 3.2.1 Low-Flow Purge Sampling Methods

Tronox installed stainless steel submersible pumps in each of the sampling wells during October 1997. A pump was installed in KM-7 during May 2000. These pumps are dedicated for evacuation and sampling purposes. Each pump is operated by a portable generator system. Each pump is suspended on Schedule 80 1-inch PVC piping and a stainless steel safety cable (in intermediate depth and deep wells), such that the intake level on each pump is placed in the approximate center of the well screened interval.

Low-flow well purging was first performed during the November 1997 sampling round following dedicated pump installation in each of the sampled wells. Low-flow sampling methods are based on EPA Region 1 "Low Flow SOP" dated May 13, 1996 and the EPA document "Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures" dated April 1996. This method was provided as an addendum to the RD/RA Sampling and Analysis Plan (SAP) deliverable submitted to EPA during May 1997 and approved by Region 10 EPA on June 6, 1997. Low-flow sampling is performed on all of the "KM" series wells with the exception of non-POC wells KM-1 and KM-10. Wells KM-1 and KM-10 are monitored for water level purposes only, although these two wells were sampled in October 2008 and in May 2009 at the request of EPA.

During sampling, flow rates are measured concurrent with drawdown in each well to assess stabilization of purged ground water. A discharge assembly is used to control the rate of discharge from each well via use of a ball valve. The assembly is used to control discharge from each well during sampling such that the amount of discharge will not allow the well to be drawn down more than 0.3 feet during purging and sampling events.

Field measurements are made through the use of a turbidity meter and flow cell. The flow cell is used to measure pH, temperature, specific conductance, and dissolved oxygen. Field data are graphed following sample collection to show stabilization of field parameter measurements with time prior to sample collection. These graphs are

presented with the semiannual data validation reports. Criteria used to determine whether the purged water has stabilized include:

- pH within  $\pm 0.3$  units;
- Temperature to within  $\pm 2$  degrees;
- Specific Conductance within  $\pm 10$  percent;
- Dissolved oxygen within  $\pm 10$  percent, and;
- Turbidity within  $\pm 10$  percent.

If the parameters do not stabilize to meet the above criteria within the extraction of three casing volumes, then a sample is obtained following the removal of not more than three casing volumes. Samples are collected from the discharge point beyond the ball valve. Samples are collected and handled in accordance with the May 1997 SAP.

### 3.3 QA/QC Data Review

QA/QC review is performed on a semiannual basis after receipt of the data from the lab. Results of the QA/QC data review are presented in the semiannual data validation report, and are not included in this annual ground water review.

## **4.0 GROUND AND SURFACE WATER QUALITY**

The May 2009 round included the collection of samples between the dates of May 26 through May 29, 2009 the (May 2009 sampling round). The October 2009 round was completed between October 6 and October 8, 2009.

### **4.1 Background Water Quality and Type**

Upgradient wells KM-1 and KM-10 were sampled during the RI, and in the fall of 2008 and spring 2009. The results from 2009 sampling of these wells indicated that wells KM-1 and KM-10 contained vanadium and molybdenum at concentrations that are one to two orders of magnitude below the RBC. Other locations sampled from background for the Tronox site included Formation Spring, and several other private wells to the north and east of the site. However, these background locations have not been sampled since 1991 because site clean-up performance is based on the POC wells and background is considered to not contain the COC. The reader is encouraged to refer to the RI report (Dames & Moore, 1995) for information on these sites.

TDS concentrations are expected to be about 500 mg/l in background wells and springs based on historic data. The largest reported TDS concentration from background locations was 579 mg/l in Formation Spring. The pH values measured at the background locations were near neutral and ranged from 6.8 to 7.4 units. Specific conductance ranged from about 840 umhos/cm in the private wells to about 970 umhos/cm in Formation Spring.

Reported background chloride concentrations were about 3.9 mg/l. Background sulfate concentrations are in the range of about 40 mg/l. Nitrate concentrations ranged from 0.11 mg/l in Formation Spring to 0.75 mg/l in private wells. Concentrations of aluminum, arsenic, chromium, manganese, molybdenum, nickel, selenium, and vanadium were less than detection at upgradient private wells and springs located to the east of the site.

Background ground water quality and type was characterized during the RI using the trilinear diagram classification method developed by Piper (1944). The Piper diagram consists of two ternary fields (triangles) for plotting percentages of cations (left triangle) and anions (right triangle), and a central diamond-shaped composite field for plotting the relative contribution of the major ion pairs. Based on the Piper plots, the site background water type plots in a specific pattern and can be classified as calcium-magnesium bicarbonate-type water.

#### 4.2 Common Ion Distributions in Ground Water

The Piper plots evaluated during the RI indicated a mixing of background-type waters beneath the site with pond seepage and contributions from leachate produced in the vadose zone. Water flowing onto the site is relatively high in calcium and low in sodium and potassium. Waters are also compositionally high in bicarbonate. Waters mixed beneath the site increase substantially in sodium, potassium, sulfate and chloride (Dames & Moore, 1995).

#### 4.3 General Ground Water Quality Parameters

##### 4.3.1 pH

The pH range in wells across the site historically indicated neutral to slightly alkaline conditions in the past. Between 1999 and 2001, field pH was lower in many of the wells near the reclaimed S-X pond including samples from wells KM-6, KM-7, KM-8, KM-12, KM-19, and near the reclaimed scrubber pond (KM-2, KM-3, KM-4, and KM-11). The lower ground water pH (range of 6.1 to 6.9) may have affected declining concentration trends for metals during the 1999 through 2001 period, causing small metals concentration increases during this period. Site distribution of pH is shown on Figure 4-1. The pH generally decreases from the east to west, ranging from about 7.1 to 6.5. During the May 2009 sampling event, pH indicated lower pH in the vicinity of the covered S-X pond area and to the south of this area, with the lowest pH occurring in the vicinity of well KM-8.

#### 4.3.2 Total Dissolved Solids

May 2009 concentrations of TDS are shown in Figure 4-2. Ground water TDS concentrations in the on-site wells ranged from 530 mg/l in well KM-9 to 9,500 mg/l in well KM-8. The secondary drinking water standard for TDS (500 mg/l) was exceeded in the Tronox POC wells. TDS is elevated in shallow wells surrounding the reclaimed scrubber pond, located to the south of the calcine tailing area that was capped in 2001. Concentrations of TDS in intermediate-depth well KM-11 is within the range of background. Beneath the west side of the site, TDS concentration in well KM-8 is substantially larger than nearby wells KM-9 and KM-13 which are slightly less than background TDS concentrations in well KM-1. This suggests that KM-1 may be affected by the calcine area. TDS is elevated above background in wells KM-6 and intermediate depth well KM-12 near the S-X pond. TDS concentration in deep well KM-19 (500 mg/l) is less than the assumed background concentration.

At off-site ground water locations, TDS concentrations are elevated in wells KM-15 through KM-18, ranging from 570 to 690 mg/l. Finch Spring, located approximately 4400 feet south of the Tronox site, indicates a TDS concentration of 520 mg/l, while Big Spring indicates slightly larger concentration of 560 mg/l.

#### 4.3.3 Turbidity

Turbidity was measured in the field during low-flow purging of the wells. Results of turbidity for the 2009 sampling events are summarized in Table 1 and presented graphically in Appendix A of the May 2009 Laboratory Data Quality Report (GET, November 29, 2009). Although turbidity is generally not considered an indicator of ground water contamination, excessive turbidity in an unfiltered sample can bias analytical results causing reported total metals concentrations to be unrepresentative of true concentrations in ground water. Turbidity is a measure of the solids and suspended organic material in a sample and is reported in nephelometric turbidity units (NTUs).

May 2009 turbidity ranged from 0.07 NTUs in well KM-4 to 70.3 NTUs in well KM-8. Well KM-8 frequently exhibited increased turbidity throughout its sampling history. Turbidity was reduced following redevelopment and removal of large amounts of sediment from this well in February 2000.

#### 4.4 Selected Major Ions in Ground Water

##### 4.4.1 Chloride

May 2009 concentrations of chloride are shown on Figure 4-3. The secondary drinking water standard for chloride is 250 mg/l. Chloride concentrations in shallow wells range from 22 mg/l in KM-13 to 1900 mg/l in well KM-8. Chloride was a predominant constituent in the S-X and scrubber ponds before these impoundments were removed from service. May 2009 ground water chloride concentrations are elevated relative to background near the reclaimed scrubber pond as indicated on Figure 4-3. Wells to the southwest and west of the S-X pond, respectively have near-background chloride concentrations while nearby well KM-8 is two orders of magnitude larger in concentration. Concentrations of chloride in deeper wells, including well KM-11 near the former scrubber pond and in wells KM-12 and KM-19 near the former S-X pond range from 2.2 to 30 mg/l. Chloride concentrations at Finch and Big Spring are 21 mg/l and 30 mg/l, respectively. Upper and Lower Ledger Spring chloride concentrations range from 4.4 to 4.6 mg/l and represent background levels.

##### 4.4.2 Nitrate Plus Nitrite

Prior to the October 1995 sampling round, samples were analyzed for nitrate, nitrite, and nitrate plus nitrite. Results indicated that nitrite concentrations are relatively small in comparison with nitrate. Currently, only nitrate plus nitrite is analyzed. The primary drinking water standard of for nitrate is 10 mg/l. Nitrate plus nitrite concentrations at Upper and Lower Ledger Springs nitrate-nitrite range from 0.68 to 0.62 mg/l, representative of background concentration for the basalt aquifer.



Nitrate plus nitrite concentrations from the May 2009 sampling round are presented on Figure 4-4. Increased nitrate plus nitrite concentrations are centered about well KM-8 to the south of the covered S-X pond, and in another ground water area beneath the site centered to the south west corner of the calcine cap. Nitrate plus nitrite concentrations are found in the ground water exceeding 5 mg/l beyond the industrial facility boundary to the south and southwest of the site towards well KM-15. Nitrate plus nitrite is noted to be larger than background concentration at Finch Spring (3.3 mg/l) and at Big Spring (4 mg/l).

#### 4.4.3 Sulfate

Sulfate indicates a similar ground water trend to chloride and TDS. Concentration distribution of sulfate in the aquifer is presented on Figure 4-5. Reported concentrations of sulfate from the May 2009 sample round range from about 3.2 mg/l in well KM-11 to 6200 mg/l in well KM-8. Increased concentrations are centered immediately west and south of the covered scrubber pond and to the south and west of the covered S-X pond. Sulfate concentrations in the deeper wells are elevated with respect to background concentration, and range from 3.2 to 110 mg/l. The secondary drinking water standard for sulfate (250 mg/l) was exceeded in monitor wells KM-2, KM-3, KM-4 and KM-8. The largest sulfate concentrations in ground water are associated with areas infiltrated by the former S-X raffinate stream. The former S-X raffinate stream was routed to the site of the former scrubber pond during operations. Off-site concentrations of sulfate are elevated above background in wells KM-15 through well KM-18, ranging from 93 to 120 mg/l.

#### 4.5 Selected Metals in Ground Water

##### 4.5.1 Arsenic

Arsenic ground water concentration ranges in Tronox monitor wells are summarized in Table 1-2 and are shown on Figure 4-6. Concentrations in ground water range from 1.3

ug/l in the on-site wells to 80 ug/l in well KM-8. Recent distribution of arsenic in on-site wells shows that arsenic is detected in wells around the reclaimed scrubber pond. Shallow wells KM-2, KM-3 and KM-4 near the former scrubber pond were 10 ug/l or greater in concentration during the May sampling round. Samples collected from off-site wells and springs indicate Finch and Big Spring levels were near the instrument detection limit (0.43 and 0.56 ug/l, respectively), for arsenic, while Upper and Lower Ledger Springs were less than detection.

#### 4.5.2 Manganese

Manganese concentrations are decreasing with time in nearly all of the wells. Manganese ground water concentrations in Tronox monitor wells are summarized in Table 1-2, and are shown on Figure 4-7. May 2009 manganese concentrations in ground water for on-site wells ranged from 4.3 ug/l in well KM-19 to 6400 ug/l in well KM-8. The RBC for manganese (180 ug/l) was exceeded in two POC wells, KM-3 (680 ug/l) and KM-8 (6400 ug/l). The RBC for manganese was exceeded in well KM-6 (210 ug/l). Manganese does not exceed the RBC at off-site well locations. Manganese was reported to range from less than the detection limit to 1.1 ug/l at Upper and Lower Ledger Spring. Manganese was 0.52 ug/l at Finch Spring and 0.46 ug/l at Big Springs during May 2009.

#### 4.5.3 Molybdenum

Molybdenum concentrations indicate an overall decreasing trend with time. Molybdenum ground water concentrations in Tronox monitor wells from 2009 are summarized in Table 1-2 and are shown on Figure 4-8. Molybdenum was a dominant metal in the S-X raffinate stream, and therefore is found in larger ground water concentrations near former pond sources. During May 2009, on-site well concentrations of molybdenum ranged between 19 ug/l in well KM-19 to 36,000 ug/l in well KM-8. Figure 4-8 illustrates that concentrations of molybdenum are elevated in areas centered to the south of the former S-X pond and to the south of the covered scrubber pond. Molybdenum exceeds the RBC (180 ug/l) in all of the on-site wells with the exception of wells KM-1, and KM-19. The molybdenum RBC is

exceeded at all off-site Tronox well locations. Finch Spring and Big Spring fell below the RBC in 2009. Molybdenum was less than the detection limit in Upper and Lower Ledger Spring during May 2009.

#### 4.5.4 Vanadium

Vanadium concentrations in ground water appear to be decreasing with time at most locations, but at a slower rate of concentration change when compared with arsenic, manganese, and molybdenum. Ground water vanadium concentrations in the Tronox monitor wells in 2009 are summarized in Table 1-2 and are plotted on Figure 4-9 from the May 2009 sampling round. Distribution of vanadium in the ground water is similar to the nitrate plus nitrite distribution.

Vanadium was a dominant metal in the S-X raffinate stream. Vanadium is detected at concentrations above the RBC (260 ug/l) in all of the on-site wells with the exceptions of intermediate well KM-11 and deep well KM-19. May 2009 vanadium concentrations in the ground water ranged between 9.4 ug/l in KM-11 to 15,000 ug/l in well KM-8. Figure 4-9 illustrates similar distribution trends to nitrate plus nitrite concentration in ground water, with the larger concentrations identified near the south end of the reclaimed S-X pond and west of the calcine cap and the covered scrubber pond. Vanadium concentrations in off-site Tronox monitor wells located southwest of the site exceed the vanadium RBC. Off-site well KM-17 (4 ug/l) remains substantially below the RBC for vanadium.

During May 2009, the vanadium concentration in Finch Spring was elevated (60 ug/l), but much smaller (3.6 ug/l) at Big Spring. Vanadium was 2.5 ug/l in Upper Ledger Springs and 1.3 ug/l in Lower Ledger Springs.

#### 4.6 Organic Compounds in Ground Water

As noted during the RI (Dames & Moore, 1995), COC semi-volatile organic compounds that include tributyl phosphate (TBP) and total petroleum hydrocarbons (TPH) originated

from the No. 1 fuel oil carrier used in the solvent extraction (S-X) process and found in the S-X raffinate stream. These compounds were detected in the former ponds and in the ground water. POC wells were sampled for total petroleum hydrocarbons and for semi volatile compounds for the detection of TBP through 1999. Organics were sampled in all POC wells in May/June 2002 as requested by EPA for evaluation in the 5-year review. Organics are not sampled at off-site locations. Currently, only well KM-8 is sampled for organics.

#### 4.6.1 Total Petroleum Hydrocarbons

TPH provides screening level estimates of total organic compound concentrations within certain hydrocarbon ranges but does not identify or provide concentrations of specific organic compounds. TPH was analyzed using Method 418.1 through 1999. This method could no longer be used because Freon was discontinued for use in the method by federal regulation. During the May 2009 sampling round, TPH was analyzed using a different extraction under Method SW846 8015B that included analysis for a range of C<sub>10</sub> through C<sub>36</sub>. TPH concentrations in POC monitor well KM-8 during 2009 ranged from 1.1 to 1.6 mg/l, greater than the RBC (0.73 mg/l), but less than previous results for this well.

#### 4.6.2 Tributyl Phosphate

TBP was used in the S-X raffinate stream and was detected at concentrations above the RBC (180 ug/l) in the wells near the reclaimed S-X and scrubber ponds during 1997. Results of previous analyses in off-site wells suggest that TBP does not exceed the RBC downgradient of the plant facility boundary. During a number of sampling events, TBP was not detected. During 1999, TBP was detected only in well KM-8 at 1400 ug/l. During 2000 and 2001, TBP was not detected in well KM-8. It is probable that some of the unknown compounds in KM-8 may be the result of degradation of the TBP compound. In 2009, TBP ranged from less than detection to 440 ug/l in well KM-8.

## 5.0 CONCENTRATION TRENDS WITH TIME

### 5.1 General

Plots of concentration versus time are shown on the graphs presented in Appendix A. These graphs of routinely sampled well and spring sites present common ion and general indicator trends, including chloride, nitrate plus nitrite, sulfate, and total dissolved solids. Metals concentration graphs include COC parameters arsenic, manganese, molybdenum, and vanadium. During 2009, graphed organic parameters include TBP and TPH from well KM-8 only because other wells were not sampled for organics.

The charts in Appendix A are annotated, where appropriate, to show periods of pond operation, the approximate time that liquid source elimination (LSE) was implemented as a remedial action, and the time that calcine capping was performed. Observed increases and decreases in ground water concentrations shown on the plots result from:

- Process changes during plant and pond operation;
- Liquid source elimination (LSE), removal of pond sediments and pond reclamation that resulted in decreased concentrations;
- Changes in ground water pH;
- Changes in annual precipitation, water ground water levels, and subsequent gradients;
- Advective transport and natural attenuation in the aquifer.

Table 5-1 provides a chronology of process and process pond events, and other site events. A number of these events have resulted in increasing and decreasing concentrations in the wells, as well as short-term concentration increases for a few of the COCs following implementation of the site remedy.

### 5.1.1 Fate and Transport of Graphed Chemical Parameters

Inorganic constituents evaluated versus time include metals and common ions. Constituents can be non-reactive and move through the ground water, unaffected by biotic (metabolism, such as microorganisms) and abiotic (adsorption, ion exchange, precipitation, hydrolysis, redox) processes. The fate of specific compounds ultimately depends on the reactivity or non-reactivity of the chemical with the media during transport.

#### **Common Ions**

Graphs of the non-reactive chemicals include chloride, a member of the halogen group that is one of the most commonly detected anions in natural water. The transport of chloride through the ground water is largely through physical (hydrodynamic) processes. Chlorides travel at essentially the same rate as the ground water (Knox et al., 1993); the graphs indicate that chloride concentrations changed more quickly in response to modifications in plant and pond operations, LSE and subsequent reclamation efforts.

Chloride ions can form complexes with a few of the positively charged ionic species, however, these complexes are usually weak, and are generally considered insignificant unless chloride concentrations are very large (Hem, 1978). Chloride is considered one of the best tracer elements, and is widely used experimentally in tracer models. In general, chloride does not enter into reduction/oxidation (redox) reactions, does not form solute complexes with other ions, does not adsorb to mineral surfaces and does not form salts of low solubility.

In the absence of plant growth, nitrate behaves as a mobile anion, similar to chloride (Drever, 1988). Nitrate concentrations can be rapidly reduced in surface waters through assimilation by aquatic plants (National Academy of Sciences, 1977). Attenuating factors for nitrates do not appear significant at the site, and concentrations may be reduced primarily through dilution in the aquifer.

The sulfate ion is chemically stable, and forms salts of low solubility with only a few metals (Hem, 1978). Once sulfate has dissolved in water, it generally remains in solution except where it is anaerobically reduced to sulfide, precipitated in sediment, released to the atmosphere, or incorporated into living organic matter.

## **Metals**

Several processes interact to control the reactivity and rate of transport of compounds in ground water. Metal ions can be strongly adsorbed to mineral surfaces in a porous medium (such as a clayey interflow zone in a basalt sequence), or to rock surfaces exposed by fractures. On the other hand, this would inhibit their transport through the aquifer when complexed with other ions; some metals can be transported at average velocities that are orders of magnitude faster than when not complexed because of changes in the attenuation properties for the complexed metal.

Changes in speciation and reactivity can result from encountering different chemistries within the aquifer. The mobilities of different oxidation states of metals such as arsenic, manganese, molybdenum, and vanadium may also differ by orders of magnitude (Allen et al., 1993).

In solution at neutral pH, the stable forms of arsenic would be arsenate oxyanions (Hem, 1978), with the dominant form being dependant on the pH of the water. Inorganic factors that maintain low concentrations of arsenic in water include adsorption by hydrous iron oxide, co-precipitation or combination with sulfide.

The transport and partitioning of manganese in water is controlled by the solubility of the specific chemical form of manganese that is present (USHHS, 1990). The solubility and speciation of manganese oxides in solution is largely a function of pH and redox potential. Manganese can also be subject to microbial activity. The principal anion associated with manganese is carbonate, although in waters with large bicarbonate concentrations, manganese bicarbonate complexes can be formed. In waters containing an excess of

1000 mg/l sulfate, manganese sulfate may become the dominant species. In extremely reduced water, the fate of manganese tends to be controlled by the formation of poorly soluble sulfide (USHHS, 1990). The tendency for soluble manganese to adsorb to soils and sediments depends largely on the cation exchange capacity and the organic composition of the soil (USHHS, 1990). Soil adsorption for manganese may be significant in the soils at the site, can be highly variable and can span five orders of magnitude, increasing as a function of organic content and ionic exchange capacity with the soil (Baes and Sharp, 1983). At small concentrations, manganese may become fixed by clays, whereas, at larger concentrations manganese may be desorbed by ion exchange with other ions in solution (USHHS, 1990).

Molybdenum is readily soluble in water, and is likely to be more mobile than vanadium in the ground water. Multiple valence states are a complicating factor in molybdenum chemistry. The anionic (molybdate) species are probably predominant in natural water (Hem, 1978).

Vanadium in the ground water at the site is predominantly found in the pentavalent state. Transport of vanadium in water and soil is influenced by redox potential, pH, and the presence of particulate (USHHS, 1990). Vanadium species have a tendency to bind strongly to mineral or biogenic surfaces by adsorption or complexing; hence it can be transported either in solution or in suspension. Adsorption may be the most significant attenuating factor at the site.

## 5.2 Trends for On-site and Point of Compliance Wells

### 5.2.1 Common Ions and General Indicators

Parameters including TDS, sulfate, and chloride indicate similar decreasing trends at the on-site non-compliance and POC wells. The pH is also a general indicator that may be affecting metals trends and concentrations noted at some locations in the past.



Based on a review of concentrations versus time for these parameters, the following general observations are made:

## **pH**

Ground water in the vicinity of the reclaimed scrubber pond had neutral to slightly alkaline pH values through early 1999, relatively unaffected by process waters during plant operation or LSE. Following the summer of 1999, a general decrease in pH was noted in the shallow ground water through 2001 and in a few wells in 2002. The pH rose in these wells following 2002 to the neutral range in 2003. Trends between 2003 and the present indicate the ground water beneath the site is in the near-neutral range, with lowered pH in the ground water near well KM-8. The site pH trend noted in 2009 was a general decrease in pH across the site from east to west.

## **TDS**

TDS concentration trends for ground water in wells located near the former site ponds and facilities are contained in Appendix A. Wells located near the former scrubber pond indicate an increase in TDS concentrations through 1995 and then show generally decreasing concentrations following remedial actions to 2009, with a flattening but decreasing trend between 2000 and the present. The TDS ground water concentration for the site in 2009 is shown on Figure 4-2.

During vanadium plant operation, increases in TDS concentrations between 1993 and 1995 are attributed to the diverted discharge of the S-X stream into the scrubber pond instead of discharging to the S-X pond. During 1997, the scrubber pond liquid was pumped to the calcine pond in preparation of the scheduled remedial action for this facility. Incidental residual liquid in the scrubber pond was released from the pond near the location of well KM-3 during the stabilization of the scrubber pond solids. As a result, well KM-3 TDS concentrations spiked during 1997 from the effects of the residual liquid ponding at the surface in the near vicinity of the well. TDS concentrations in well

KM-3 have been decreasing since November 1997 following pond closure and reclamation.

Shallow wells near the former scrubber pond demonstrated larger variability in TDS concentrations between sampling events prior to pond closure. All wells continue to indicate overall decreasing trends, although concentrations rose slightly in May 2006 and decreased to the present range of concentration. TDS ground water concentrations in well KM-3 appear to show greater seasonal variability between 2000 and the present, compared with other shallow wells in this area. Seasonal increasing/decreasing trends may account for some of the variability between rounds. Intermediate depth well KM-11 demonstrated comparatively little variability.

Wells KM-5 near the historic scrubber pond and wells KM-9, KM-12, and KM-13 located near the west side of the facility or near the reclaimed S-X pond indicate a general TDS concentration decrease with time, and smaller overall decreases following 2000 as concentrations approach background. A spike in concentration is noted in the 2006 data results. Well KM-6 indicated slightly increasing concentrations through 1999, followed by a decreasing TDS trend through 2002, and a flattening of the trend between 2001 and the present with a spike note in the spring of 2006. Deep well KM-19 is near background concentration with respect to TDS, but shows an overall decreasing trend. Well KM-8 indicates substantial variability with time, and suggests an overall decreasing trend between 1995 and 2005. TDS is variable in well KM-8 ground water after 2005, but TDS has an increasing trend between 2005 and 2009. Seasonal increasing/decreasing trends account for some of the variability between rounds.

## **Chloride**

Chloride concentration trends in ground water for wells located near the former pond facilities are contained in Appendix A. Trend graphs in Appendix A show that ground water in the vicinity of the reclaimed scrubber pond demonstrates an increase in chloride concentration for shallow wells during pond operation through 1995 as a result

of S-X stream discharges to this location. Chloride concentrations have decreased since the RI to the present levels noted on Figure 4-3. Currently, chloride concentrations are substantially greater near the scrubber pond than at other site locations, except well KM-8 near the former S-X pond. Shallow wells near the scrubber pond display variable chloride concentrations through 1997 between sampling events as the result of unlined pond operations. Intermediate depth well KM-11 is less affected by pond operational changes and indicates a more even (smoother) chloride trend with time. All wells monitoring ground water in this area demonstrate decreases in chloride concentrations between November 1997 and the present. The decreasing chloride trend in KM-2 slowed after 2003, but continues to decrease to the present. Chloride concentration trends are nearly identical to TDS trends.

Wells located near the west side of the facility or near the former reclaimed S-X pond indicate chloride concentration decreases with time, with a general flattening of the trends between 2001 and the present. Well KM-6 chloride concentrations are also decreasing, but remain elevated above other wells in this area. A number of wells demonstrate an increase in concentration during the spring of 2006. Well KM-8 chloride concentrations show seasonal variability with larger concentrations in the fall, but generally decreasing concentrations through 2000, followed by a lack of seasonality in the data through 2004. Concentrations of chloride suggest an increasing trend in well KM-8 between 2005 and 2009.

## **Sulfate**

Sulfate concentration trends for wells located near the former pond facilities are contained in Appendix A. Sulfate trends for ground water in wells located near the reclaimed scrubber pond exhibit decreasing trends that are comparable to chloride. An increase is noted in sulfate concentrations through 1996 as a result of S-X stream discharges to this location. Sulfate shows a general concentration decrease to the present distribution in ground water shown on Figure 4-5. Concentration increases in well KM-3 in 1997 resulted from incidental residual liquid in the scrubber pond that was

released from the pond during remediation and reclamation activities. As the direct result, concentrations of sulfate in well KM-3 spiked during 1997. KM-3 sulfate concentrations decreased since that time. Sulfate concentrations in wells KM-2 and KM-11 have been relatively steady between 1999 and the present. Sulfate concentrations in well KM-4 indicate decreasing concentration trends since 1997. Well KM-11 was less affected by plant operations, and shows an even (smoother) trend with time and a longer duration of peak sulfate concentrations. Sulfate concentration decreases near the scrubber pond have slowed since 2007 and the present.

Wells KM-5, KM-9, KM-12, and KM-13 sited near the west side of the facility or near the former S-X pond demonstrate a sulfate concentration decrease with time with a flattening after 2000. Well KM-19 sulfate concentrations decreased to near background concentrations in 1998. Well KM-6 indicated little change with time through 2000, and then began to decrease though the present level, with a small spike note in the spring of 2006. Sulfate concentration decreases near the scrubber pond have slowed between 2007 and the present. Well KM-8 sulfate concentrations show similarities to chloride and TDS trends. Well KM-8 sulfate continued to indicate decreasing trends between 1995 and 2005. Slight increasing concentrations are noted between 2005 and the present. Less seasonal variability in concentration is noted between 1999 and 2006, with more variability noted between 2006 and the present. Increased concentrations were noted in the fall during periods of lower water level elevations in this well prior to 2005. Since 2005, larger sulfate concentrations in well KM-8 occur during the spring sampling round.

### **Nitrate plus Nitrite**

Nitrate plus nitrite concentration trends for wells located near the former pond facilities are contained in Appendix A. Wells KM-3 and KM-11 located near the reclaimed scrubber pond have relatively small nitrate plus nitrite ground water concentrations and trends, and a relatively flat trend since LSE was implemented. Well KM-2 initially shows relatively larger nitrate plus nitrite ground water concentrations, with declining

concentrations between 1999 and 2003, followed by a flattened trend with a spike in concentration occurring in 2006. Well KM-4 nitrate plus nitrite concentrations indicate an increasing concentration trend beginning in the fall of 2001 through the present. Current nitrate plus nitrite ground water concentrations in well KM-4 are comparable to concentrations noted during the period when the scrubber pond was operational.

Shallow wells near the west side of the facility or near the former S-X pond indicated a spike in nitrate plus nitrite concentration between 1993 and 1994 and variable concentrations with time. Most wells show a decrease in nitrate plus nitrite concentration between 1997 through May 2000. Concentrations in wells KM-5 and KM-6 suggest an increasing trend between 2001 to the present. Nitrate plus nitrite ground water concentrations in well KM-7 have been increasing since 2001. Wells KM-13 and KM-9 also suggest slightly increasing nitrate concentration since 2004. Deeper wells KM-12 and KM-19 indicate little change with time. Well KM-8 concentrations spiked in 1994 and 1997, and decreased through 2001. An increasing nitrate plus nitrite concentration trend is noted in KM-8 between 2001 and 2009. The current KM-8 nitrate plus nitrite concentration range is larger than nitrate plus nitrite concentrations noted during pond operations.

## 5.2.2 Metals Concentration Trends

Graphs of metal concentrations versus time include the group of metals identified by EPA as COC. COC metals versus time are presented in Appendix A and described in the following sections.

### **Arsenic**

The arsenic risk based concentration (RBC) is 10 ug/l. This concentration value is based on the Federal MCL for drinking water. The results from May 2009 indicate that wells KM-2, KM-3, KM-4 and KM-8 exceed the drinking water standard for arsenic, as shown on Figure 4-6.

Arsenic versus time plots presented in Appendix A indicate that wells located near the former scrubber pond denote ground water arsenic concentrations that are near the RBC (10 ug/l). Well KM-3 demonstrates a slight increase in arsenic through 1997, primarily during the time-period that the S-X stream was diverted to the scrubber pond. Well KM-2 spiked in 1994 and has decreased since that time. Well KM-4 spiked in 1994 and again during 1997. Concentration spikes may have been related to discharge of the S-X stream to the scrubber pond. Arsenic concentrations have generally been decreasing near the former scrubber pond since LSE and reclamation in 1997, with a flattening of the trend since 1999.

Wells near the west side of the facility or near the former S-X pond indicate an arsenic concentration decrease with time through 1995. Sample results from the October 2007 and May 2009 sampling indicated that the use of lower detection limits did not result in an increased number of wells exceeding the arsenic RBC. However, arsenic concentrations in 2009 appear smaller than those levels noted in 1998 for these wells.

Well KM-8 indicated an increasing trend following May 1995 when the pond was taken out of service, with a peak concentration occurring during 2002. The cause for the increase in arsenic concentrations since closure of the S-X pond is unknown. Concentrations of arsenic have decreased between 2002 and May 2006. Concentrations increased again between 2006 and 2009.

## **Manganese**

Ground water manganese concentration trends in wells located near the former pond facilities are contained in Appendix A. Wells located near the former scrubber pond show variable manganese concentrations throughout operation and then small decreases to the present. Increases in the concentrations of manganese during earlier time periods are attributed to S-X stream discharge into the scrubber pond. Wells KM-3 and KM-4 show significant variability between sample rounds through 1997. Manganese concentrations in well KM-4 ground water spiked during 1994 and

decreased through the present. Manganese concentrations in well KM-3 spiked during 1997, decreased with time through 2000, then demonstrated a steady increasing trend to the present. Well KM-3 is the only well in this group near the scrubber pond that currently exceeds the RBC for manganese.

Wells near the west side of the facility or near the former S-X pond indicated a decrease in manganese with time between 1995 and 2000. Trends for manganese have flattened from 2000 to the present. Wells KM-6 and KM-7 indicate considerable manganese concentration variability with time that suggests seasonal trends, although this was less notable between 2002 and 2004. KM-6 indicated a relatively stable trend between 2004 to the present, with a spiking manganese concentration in 2006. Deep well KM-19 ground water is at background concentration levels.

Manganese concentrations in well KM-8 continue to exceed the RBC. During operations, the well KM-8 manganese trend showed decreasing concentration through 1994, followed by increasing concentrations through 1997. Concentrations of manganese have fluctuated, but generally began to decrease several years following LSE and reclamation efforts in 1997. However, manganese concentrations in well KM-8 have risen since 2004 to the present, with substantially larger seasonal variability noted between 2004 and 2009. Concentrations of manganese are currently within the range noted during pond operation.

## **Molybdenum**

Ground water molybdenum concentration trends in wells located near the former pond facilities are contained in Appendix A. Molybdenum trends with time are comparable to sulfate trends.

Wells located near the former scrubber pond indicated decreasing molybdenum concentrations with time following LSE and reclamation through 2000. Following 2000, wells near the scrubber pond generally indicate decreasing molybdenum concentrations

following 2000 to the present, although at a slower rate of decrease. Molybdenum concentrations in well KM-3 spiked in 1997 during the remediation and stabilization of the scrubber pond solids. Well KM-3 molybdenum concentrations increased between 2000 and 2003 then decreased to the present levels. Seasonal concentration peaks are noted during the spring sampling rounds.

Wells KM-5, KM-9, KM-12, KM-13, and KM-19 located near the west side of the facility or near the reclaimed S-X pond indicated a concentration decrease with time through 2000, with much smaller decreasing trends noted between 2000 and the present. Concentration trends have essentially flattened since 2007. Well KM-6 indicates an overall decreasing molybdenum trend through 2004, with a flat trend through May 2009 and a spike occurring in 2006. Larger molybdenum concentrations take place during periods of higher water level elevation (spring sampling) in this well.

Molybdenum concentrations in well KM-8 peaked during late 1994. Well KM-8 indicates substantial concentration variability with time similar to the common ion trends and an overall decreasing trend with time following LSE and reclamation events through 2005. Molybdenum concentrations in KM-8 bottomed out in 2005 and then began to suggest an increasing and seasonal trend through 2009.

## **Vanadium**

Vanadium ground water concentration trends in wells located near the former pond facilities are included in Appendix A. Shallow wells located near the reclaimed scrubber pond indicate decreasing vanadium concentrations for most wells with time following LSE in 1997. Well KM-11 ground water vanadium concentrations are an order of magnitude below the RBC, and demonstrate little change since 1997. Well KM-3 trend indicates a flattening of the vanadium concentration between May 1998 and May 2001, and a steady trend in concentration of vanadium following capping of the calcine. Concentrations in well KM-3 have been seasonal but have not substantially decreased since 2005. Well KM-4 vanadium concentrations increased substantially through 1997



and decreased with time through early 2000. Concentrations of vanadium in ground water from well KM-4 increased between 2004 and 2008 with a large spike in concentration in 2006, and a possible decreasing trend after 2008. Well KM-2 vanadium concentrations increased through 1996 as the result of the S-X discharge to the scrubber pond, and decreased substantially in 1997 when the pond was reclaimed and the calcine pond dried. The trend for vanadium concentrations in well KM-2 ground water have been essentially flat since 2005.

Wells KM-5 which is located near an historic scrubber pond and wells KM-6, KM-7, KM-9, KM-12, KM-13, and KM-19 located near the west side of the plant facility and near the reclaimed S-X pond indicate that vanadium concentrations decreased more quickly with time prior to 2001. Wells KM-5, KM-9, KM-12, KM-13, and KM-19 continue to decline in concentration to the present at a slower rate since 2001. Wells KM-6 and KM-7 declined in concentration through 2004; however concentrations of vanadium in KM-6 and KM-7 have generally been flat or have increased since 2004. Wells KM-5, KM-6 and KM-7 ground water vanadium concentrations spiked in 2006.

Well KM-8 vanadium concentrations began to decrease in KM-8 beginning in 1992 (during plant operations) and continued to decrease following LSE in 1997. In May 1998, vanadium concentrations began to increase in well KM-8 with an increasing trend through 2004. Vanadium concentrations in well KM-8 ground water decreased between 2004 and 2006 but have been relatively steady between 2006 and the present.

### 5.2.3 Organics

#### **Total Petroleum Hydrocarbons**

KM-8 is the only POC well routinely sampled for TPH. TPH concentrations with time for well KM-8 are contained in Appendix A. Concentrations of TPH decreased with time in well KM-8 to less than detection in 1999. During 2000 and 2001, TPH ground water concentrations increased above historic ranges. Concentrations have decreased since

2000 to current levels of about 1.1 mg/l. The TPH ground water concentration trend in this well indicates a substantial decrease since 2000 with steady concentrations demonstrating seasonal trends since 2005.

### **Tributyl Phosphate**

KM-8 is the only POC well routinely sampled for TBP. Well KM-8 TBP concentrations with time are charted in Appendix A. Concentrations of TBP decreased through 2005 in well KM-8. Concentrations appear seasonal, with larger concentrations generally noted in the spring sampling events. Concentrations have been within the same seasonal range since 2004.

#### **5.2.4 Conclusions of On-Site Well Concentration Trends**

Conclusions drawn from the review of on-site well concentration trends include:

- Nearly all on-site wells exceed the RBC for molybdenum and vanadium. Nearly all wells demonstrate decreases in concentration with time, although the decreasing trend for some general indicators and for molybdenum and vanadium has flattened since 2004. Some concentration increases have been noted in a few wells since 2004, particularly in areas near or immediately downgradient of the former S-X pond and scrubber pond. Vanadium ground water concentrations bottomed out in wells KM-6 and KM-7 in 2004 and spiked in 2006. Well KM-8 indicated a vanadium ground water concentration decrease through May 1999. Vanadium concentrations increased in well KM-8 since then and have not returned to 1999 concentrations.
- Concentrations of common ions generally decreased through 2009 in almost all POC wells following LSE and surface reclamation.
- Concentrations of manganese declined following LSE to less than the RBC in all on-site wells with the exception of KM-3 and KM-8 that currently demonstrate increasing concentration trends.
- Several shallow wells indicate seasonal variability in concentration, with larger concentrations occurring in the spring. For some wells, including KM-6 and KM-8, this seasonal trend was less noteworthy for a period between 2002 and 2006.

- TPH continues to slightly exceed the RBC in KM-8, although trends indicate a relatively flat but seasonal trend that is currently above the RBC.
- TBP is currently detected in KM-8, although this TIC was not noted between 1998 and 2001. TBP is also seasonal and an increasing trend is noted between 2005 and 2008.
- Arsenic remains above the arsenic MCL in several shallow ground water wells around the covered scrubber pond S-X ponds.

### 5.3 Off-Site Well Concentration Trends

The following sections provide a discussion of concentration trends with time for the off-site wells (Tronox wells located beyond the POC), located to the south on the property previously owned by Larry Hopkins, but purchased by Tronox in 2004. Off-site wells that are now on Tronox property include wells KM-15, KM-16, KM-17, and KM-18. Changes in concentration with time are generally smaller in the off-site wells as a function of their greater distance from the site and pond areas that impacted ground water quality.

In general, concentrations and concentration trends observed in paired shallow and intermediate wells KM-15 and KM-18 are similar for some of the monitored parameters as the result of the downward vertical gradient noted between water levels in these wells. Concentrations decreased steadily in these wells since the time of the remediation of the MAP ponds in 1993. Wells KM-15 and KM-18 appear to be more directly affected by activities on the west side of the plant facility. Well KM-16 indicates seasonal fluctuations and demonstrates more of a delayed response to LSE and pond basin remediation performed between 1995 and 1997. Well KM-16 also demonstrates similar concentration trends to on-site well KM-6. Well KM-17 has been impacted by operations on the east side of the site that occurred in the vicinity of the former scrubber pond. Well KM-17 has relatively large concentrations of common ions and molybdenum, but appears minimally impacted by arsenic, manganese, and vanadium.

### 5.3.1 Common Ions and General Indicators

Based on a review of concentrations versus time for these parameters, the following general observations are described below. Graphs of concentrations versus time that are the basis for identifying the trends are contained in Appendix A.

#### **pH**

Off-site pH concentrations indicate a similar trend to on-site wells, with a general decrease in pH noted in late 1999 through 2001 from previous neutral to slightly alkaline conditions. Figure 4-1 shows that the 2009 pH in the off-site ground water was slightly less than in wells KM-15, KM-16 and KM-18, with a general decrease in pH in a westerly direction.

#### **TDS**

Paired wells KM-15 and KM-18 have similar TDS concentrations, and show an overall decrease in concentration with time through 2009, with a flattening of the trend between 2003 and 2005. Well KM-16 indicates a decreasing trend with time following LSE, but also demonstrated a spike in concentration between 2003 and 2006. Seasonal trends may account for some of the variability between rounds. Increased concentrations occur during periods of higher water level elevation in well KM-16.

Well KM-17 has the largest of the off-site well TDS concentrations. Concentrations in this well result from historic operations at the scrubber pond.

#### **Chloride**

Wells KM-15 and KM-18 indicate matching concentrations, and show an overall decrease with time, beginning prior to LSE. The trend flattened between 2003 and 2009. Concentrations of chloride in wells KM-16 and KM-17 lag wells KM-15 and KM-

18 and were directly affected by LSE, since wells KM-15 and KM-18 indicated an earlier decrease in chloride. KM-16 indicates a larger decrease following 1999, but concentrations became flat in this well following 2008. Well KM-17 chloride concentrations are the largest identified in the off-site wells. This well has been affected by lateral dispersion from the scrubber pond, and indicates variably decreasing concentrations since pond reclamation in 1997, but also appears to have a flatter trend following 2008.

### **Sulfate**

Ground water in wells KM-15 and KM-18 indicate nearly identical sulfate concentrations, and show an overall decrease with time since initial sampling in 1992. This trend flattened in 2000. Well KM-17 sulfate concentration trends appear to be decreasing following LSE and scrubber pond reclamation efforts in 1997, although KM-15, KM-16 and KM-18 have been relatively flat since 2004. Sulfate concentrations were within a narrow range for all four wells in 2009.

### **Nitrate plus Nitrite**

Concentrations of nitrite plus nitrate decreased following LSE in the off-site wells. Well KM-17 has the smallest nitrite plus nitrate ground water concentrations of all of the off-site wells and demonstrates the smallest variability with time, but indicates an overall decreasing trend. Well KM-15 nitrate plus nitrate concentrations are larger than concentrations found in the deeper well KM-18. Concentrations in the ground water from both wells decreased through 2001 then became seasonal with larger concentrations noted in the spring sampling event.

Well KM-16 shows a decreasing trend with time through 2001, with notable seasonal increasing and decreasing trends similar to well KM-15 nitrite plus nitrate. Concentrations of nitrite plus nitrate increased during periods of higher water level

elevations in this well. Wells KM-15, KM-16 and KM-18 demonstrate an increasing nitrite plus nitrate trend since 2001 with notable seasonality in the data.

### 5.3.2 Off-Site Metal Concentration Trends

Graphs of metal concentrations versus time include the group of metals identified by EPA as COC. COC metals versus time are presented in Appendix A and described in the following sections.

#### **Arsenic**

All off-site wells are well below the arsenic method detection limit of 5 ug/l and the RBC of 10 ug/l, as shown on Figure 4-6.

#### **Manganese**

Off-site wells are below the RBC for manganese, as shown on Figure 4-7. Concentrations of manganese in well KM-15, KM-16, and KM-18 decreased with time from initial concentrations that were greater than the RBC. Well KM-15 concentrations are approaching concentrations noted in deeper well KM-18. Well KM-17 ground water manganese concentrations remain low, near the detection limit. Well KM-16 indicates an overall decreasing trend with time and seasonal trends between rounds. Increased concentrations occur during spring sampling rounds. Decreases in manganese concentrations in KM-16 show a lag time behind the other off-site wells.

#### **Molybdenum**

All off-site wells currently exceed the molybdenum RBC of 180 ug/l, with distributions of molybdenum in the ground water as shown on Figure 4-8. Ground water molybdenum concentrations in wells KM-15 and KM-18 are very similar, and both peaked during pond operation and then began to decline after 1993. Both wells have similar

concentration trends and both indicate significant concentration decreases with time through 2000. The decreasing trend flattened between 2000 and 2009 with a spike noted in 2006. Well KM-16 indicated a steady molybdenum concentration with time through 1997. Molybdenum concentrations decreased in May 1998, approximately six months following LSE and pond reclamation. Well KM-16 continued the decreasing trend through 2004 with notable seasonality through 2001. Increased concentrations occurred in the spring during periods of higher water level elevation. KM-16 molybdenum concentrations spiked in the spring of 2006, and then decreased to the current concentrations that remain above the RBC and are comparable with 2004 concentrations. KM-17 molybdenum concentrations increased between 1998 and 2003 then declined slightly to the current concentrations that remain above the RBC but within the molybdenum ranges noted in the ground water from wells KM-15 and KM-18.

## **Vanadium**

Off-site wells exceed the 260 ug/l RBC for vanadium with the exception of well KM-17, which has relatively unchanged concentrations since November 1997. Concentrations of vanadium in wells KM-15 and KM-18 peaked prior to 1993 during pond operations and began to decline after diversion of the S-X stream to the scrubber pond and elimination of the MAP ponds. Both wells KM-15 and KM-18 have parallel decreasing concentration trends, with well KM-18 having a consistently lower concentration. Both wells indicate decreasing concentration trends through 2000, with a flattening of the trend to the present. Well KM-16 has the largest ground water vanadium concentration of all off-site wells. Well KM-16 vanadium concentrations spiked in 2006 then decreased to within the range of 2004 concentrations.

### **5.3.3 Organics**

Organics are no longer sampled in the off-site wells. TPH was last sampled during November 1996. Concentrations of TPH remained relatively unchanged with time. Concentrations of TPH during 1996 were reported at the detection limit. TBP concentrations increased through May 1994 in the off-site wells, and then decreased to

less than the RBC in October 1995. TBP in well KM-16 was not detected after May 1993.

#### 5.3.4 Conclusions of Off-Site Well Concentration Trends

Conclusions drawn from the review of off-site well concentration trends include:

- Off-site wells exceed the RBC for molybdenum and vanadium (except KM-17 that is less than the RBC for vanadium), but are below the RBC for arsenic, manganese, and assumed to be below the RBC for organics. Concentrations decreased with time following LSE, although a concentration spike was noted in some wells in 2006.
- Concentrations of common ions and TDS continue to generally decrease with time following LSE and reclamation. Nitrate plus nitrite concentrations suggest strongly seasonal trends with a rising trend in ground water monitored by wells KM-15, KM-16 and KM-18 since 2001. Concentration decreases of common ions have flattened in KM-16 with a number of parameters spiking in concentration in 2006.

#### 5.4 Off-Site Surface Water Quality Concentration Trends

Tronox routinely monitors surface water quality at four spring locations on a semiannual basis. Springs that are sampled include Finch Spring, Big Spring, and Upper and Lower Ledger Springs. Spring samples are analyzed for general indicator parameters, common ions, and metals. Concentrations versus time graphs for these springs are presented in Appendix A.

Finch Spring originates from the base of the Finch Spring Fault scarp, approximately 4000 feet to the south of the Tronox facility. Finch Spring has been routinely sampled since 1991. Flow from this spring discharges to a pond that flows to Kelly Park. Discharge from Finch Spring is typically less than 50 gpm.

Big Spring is located at the most downgradient discharge point in the valley, adjacent to the Bear River. Big Spring is the most distant spring relative to the site, located approximately 2.8 miles south of the facility and south of the town of Soda Springs and



is believed to be impacted by upgradient sources, including the Monsanto facility. Big Spring emerges from alluvium at the south end of the valley floor and flows into Hatchery Creek and then into the Bear River. Big Spring was initially sampled by Tronox in 1993. Flow from this spring is considerably greater than Finch Spring discharge, although Big Spring flow was smaller between 2001 and 2004 due to several years of below normal precipitation. Discharge from Big Spring was approximately 17 cfs in May 2009.

Upper and Lower Ledger Spring discharge at a location approximately 3,300 feet to the southeast of Finch Spring. Both springs issue from the basalt aquifer. During June 2000, EPA requested that Tronox resume routine sampling of Upper and Lower Ledger Springs. These springs were first sampled by Tronox in 1991. These springs are a source of drinking water for Soda Springs. Sample results with time are presented for Upper and Lower Ledger Springs in Appendix A. Concentrations of metals are typically less than detection in Upper and Lower Ledger Springs, although molybdenum and vanadium are occasionally detected at concentrations near the detection limit.

#### 5.4.1 Common Ions and General Indicators

### **TDS**

TDS concentrations at Finch Spring increased through October 1994 as the result of pond operation at the site and changes in the discharge of the S-X stream. TDS concentrations decreased steadily between 1995 and 2002, with a smaller seasonally-affected decreasing trend between 2002 and 2009.

Small seasonal trends are noted in the Big Spring TDS data. Concentrations of TDS at Big Spring decreased consistently since 1996 to current levels of under 600 mg/l that are comparable to, but slightly greater than Finch Spring. TDS concentrations decreased in Big Spring between 1995 and 2001. Between 2001 and 2009, the decreasing TDS trend flattened when compared with the rate prior to 2001.

TDS concentrations in Ledger Springs were 470 mg/l in May 2009. Lower Ledger generally has indicated slightly larger concentration than Upper Ledger in past sampling events. TDS concentrations at the Ledger Springs are less than the concentrations at Big and Finch Spring, and are more representative of background water quality concentrations. Concentrations appear seasonal, and trends suggest generally decreasing TDS concentrations since 2000.

## **Chloride**

Concentrations of chloride at Finch Spring increased through October 1994, peaked again in late 1996, and then decreased in concentration through May 2009 below 1991 levels. Concentrations leveled off in 1999 but then continued a decrease through the present. Chloride is a conservative tracer because transport in ground water is generally through the hydrodynamic process, traveling essentially at the same rate as ground water flow. Therefore, changes in chloride concentrations at Finch Spring reflect process and remedial changes at the plant.

Chloride concentrations decreased in Big Spring after 1996. Big Spring is located at the most downgradient discharge point in the valley, and decreasing concentrations of chloride may be related to factors affecting water quality not related to the Tronox facility. The decreasing chloride trend continued, but flattened between 2001 and 2009. The chloride concentrations at Ledger Springs are an order of magnitude less than chloride concentrations at Big and Finch Springs and represent background. Chloride concentrations at both Ledger springs are about 4 mg/l.

## **Sulfate**

Sulfate trends at Finch Spring are remarkably similar to the chloride trends. Sulfate peaked in October 1994 and 1996, and then decreased to the present concentrations. Changes in Finch Spring sulfate concentrations are related to former S-X stream discharges to the scrubber pond. Concentrations of sulfate at Finch Spring decreased in

2009 to within or below the range of 1991 concentrations. The sulfate trend at Finch Spring is relatively flat since 2005. Sulfate concentrations at Big Spring are about 30 percent greater than the Finch Spring concentration. Big Spring also indicates a steady decrease with time since 1994 through 2009. The Ledger Springs sulfate concentrations are also smaller than sulfate concentrations at Big and Finch Springs, and range from about 31 to 32 mg/l. Seasonal trends are noted, but no long-term trends are noted for sulfate in Ledger Springs.

### **Nitrate plus Nitrite**

Nitrate plus nitrite concentrations are similar at Finch and Big Springs locations, with slightly larger concentration at Big Springs. Both locations suggest slight seasonal trends in the data, with larger concentrations occurring in the fall season. Both locations indicate generally decreasing concentration trends with time through 2001 and a flattened trend between 2001 and 2009. Ledger Spring nitrate plus nitrite concentrations are an order of magnitude lower than nitrate plus nitrite concentrations at Big and Finch Springs.

#### **5.4.2 Metals Concentration Trends**

Graphs of metals versus time are presented in Appendix A and described in the following sections.

### **Arsenic**

Arsenic concentrations are less than the RBC and reporting limit at all spring surface water locations during 2009.

## **Manganese**

Concentrations of manganese are less than the RBC and generally less than, or near the reporting limit at Finch Spring. Concentrations of manganese are less than 1 ug/l at Upper and Lower Ledger spring locations in May 2009.

## **Molybdenum**

Historic increases and decreases in molybdenum concentrations for Finch Spring were noted during the RI to be related to changes in the discharge locations of the S-X stream. Concentrations of molybdenum at Finch Spring indicate decreasing trends through 1996. After 1996, the molybdenum concentration then increased sharply and peaked in July 1997. Concentrations of molybdenum have decreased steadily between 1997 and 2009 and are currently less than the RBC.

Molybdenum concentrations increased at Big Spring through 1997 then decreased through 2000. Concentrations of molybdenum increased slightly in 2001, also noted at Finch Spring. The decreasing trend in molybdenum flattened in 2003 and 2004 but continued after 2004 with an overall decreasing trend through 2009. The molybdenum concentration was less than the RBC in 2009.

Molybdenum was estimated less than detection at the Ledger Springs in May 2009. Molybdenum has been detected infrequently at levels near or below the reporting limit since 2000.

## **Vanadium**

Finch Spring demonstrates an overall increasing trend in vanadium since monitoring began. Vanadium concentrations increased at Finch Spring through 2001. Concentrations of vanadium peaked in Finch Spring during 2001 at a concentration of 92 ug/l and then demonstrated a decreasing trend to 60 ug/l in May 2009. Increases in

vanadium concentrations at Finch Spring are believed to be the result of operational S-X stream discharges to the scrubber pond. Vanadium was detected at a small concentration of 3.6 ug/l in Big Spring in May 2009. Vanadium concentrations ranged from 1.3 to 2.5 ug/l at the Ledger Springs in May 2009.

## 6.0 PROJECTED CONCENTRATION DECAY TRENDS

### 6.1 General

COC concentration trends with time and projected trends for these wells are presented in Appendix B. Projected trends are based on the post-LSE monitoring period data. The projected period into the future varies between wells in order to demonstrate the approximate time when the COC is predicted to fall below the RBC. The purpose of the trend evaluation is to assess the likelihood of the remedy to achieve the cleanup goals. To accomplish this, ground and surface water COC data (specifically molybdenum and vanadium and manganese for KM-3 and KM-8) were evaluated for the period following cessation of the last of the uncontrolled waste stream discharges (October 1997) to estimate the relative change in ground water COC concentrations that resulted from LSE. The calcine was not capped until approximately 4 years after LSE, so effects of the infiltration and ponding in the calcine affected some of the early time COC concentration data for some of the wells, including wells KM-2, KM-3 and KM-4. Methods used to evaluate the data include regression analyses that are discussed in this section with the regression curves, regression equations and coefficients presented in Appendix B.

Existing data collected as part of the monitoring program were evaluated using regression analysis. Two data sets were evaluated. The first data set included vanadium and molybdenum data from November 1997 to October 2009, the period following the implementation of the remedial actions. This truncation was prepared to focus the evaluation on the trends following the implementation of the remedial actions. The second set of data includes vanadium and molybdenum data results from a shorter period of time (May 2004 through October 2009). These data were evaluated in conjunction with the November 1997 through October 2009 data set to assess whether the more recent data set (includes the spiked 2006 concentrations) demonstrate trends that are notably different from the overall LSE time period. These evaluations were done for each point of compliance monitor well, and for Finch Spring and Big Spring.

The purpose of this evaluation was to estimate when cleanup performance standards can reasonably be expected to be met.

## 6.2 Regression Analysis

An analysis using the November 1997 through October 2009 and the May 2004 through October 2009 data sets provide an estimate when these concentrations may potentially fall below their respective RBC for molybdenum and vanadium. TBP and TPH data from wells other than KM-8 are not available, and therefore are not considered in this analysis.

Arsenic was detected during the RI in the limestone settling ponds at a concentration of 190 ug/l with much smaller concentrations in the MAP (14.7 ug/l) and scrubber pond (8 ug/l). Arsenic is not evaluated in the regression analysis because concentrations are frequently found to be less than detection in most wells between 1999 and 2007. Following 2007, the arsenic method detection limit was lowered to 5 ug/l. There is no clear trend for arsenic in well KM-8, or in the wells (KM-2, KM-3 and KM-4) surrounding the covered scrubber pond where arsenic concentrations are close to or just greater than the RBC. Near the historic S-X pond, well KM-8 demonstrates the largest arsenic ground water concentration with no clear trend therefore, prediction of the time for arsenic concentrations in ground water to fall below the RBC is uncertain.

Manganese is evaluated for wells KM-3 and KM-8. Both wells KM-3 and KM-8 demonstrate recent increasing manganese concentrations in ground water with time. The remaining wells demonstrate that manganese concentrations in the ground water are currently less than the RBC.

Projected concentration decay trends are estimated where possible, using a regression trend curve fitted to the real-time monitoring data from ground water where the COC currently exceed the risk-based concentrations of manganese, molybdenum and vanadium. These COC were selected because most of the risk in ground water is

driven by the occurrence of these metals. The time period for data used to evaluate the projected COC trends included the period from November 1997 (the first round of ground water collected from the monitoring points following LSE) through the October 2009 round.

Data analyzed to predict future trends include ground water results obtained from wells KM-2, KM-3, KM-5, KM-6, KM-8, KM-9, KM-12 and KM-13 that are located on the vanadium plant site; and off-site wells KM-15, KM-16, KM-17 and KM-18 that are located south of the site. Analysis for Finch and Big Spring molybdenum trends are also presented. Results of the regression analysis are presented in Appendix B. Results of the predictions based on the 1997 to 2009 data are summarized in Table 6-1. Predictions for COC based on the 2004 to 2009 data are summarized in Table 6-2.

Most of the wells, both on and off the industrial site and the springs demonstrate decreasing concentrations with respect to molybdenum and vanadium based on the data from the 12-year LSE evaluated period. However, as the result of increasing concentration trends between 2004 and 2006 in ground water downgradient of the former scrubber and S-X ponds, or based on flattened trends following 2006 in some wells, the estimated time to reach the RBC can not be reliably predicted. The wells that appear somewhat uncertain to reach the RBC following LSE include wells KM-2, KM-3 and KM-4 that surround the former scrubber pond, and wells KM-6, KM-8, KM-15 and KM-16 that are south and downgradient of the covered S-X pond basin and the site. Well KM-5 located near the former historic scrubber and MAP ponds has achieved molybdenum cleanup levels, but the period of time required to achieve the vanadium RBC will be substantially greater.

Analysis of 2004 to 2009 vanadium data from this group of wells shown in Table 6-2 indicates that the time to reach the RBC could be substantially longer than the estimated times from the 12-year data set. Conversely, estimated trends based on the most recent five years of data for a few wells suggest that the rate of COC decrease is occurring more quickly when compared with the full 12-year LSE period (November



1997 though 2009). The 2004 to 2009 data set, for the most part, shows decreasing trends in COC at a rate that is slower than immediately following LSE. However, the results from the regression analysis of the 2004 through 2009 data should not be relied upon for prediction of time to reach the RBC in ground water. These data (2004 through 2009) implicate COC mass loading to the aquifer in the absence of leaking pond sources during this time period.

#### 6.2.1 Analytical Method

Existing ground water data were evaluated using a statistical forecast function for exponential decay. A forecast calculates or predicts a future value by using existing values. The predicted value is a y-value (future concentration of a COC in ground water) for a given future date. The known values are ground water data from the wells. A forecast statistically predicts future values based on a regression function of a range of known data or known x- and y-arrays. Regression analysis estimates the relationship between variables, so that a given variable can be predicted from one or more other variables.

Data curves for the ground water concentrations shown in Appendix B were generated using an exponential function that describes decay of a substance and calculates the least squares fit through points by using the equation:

$$y = ce^{-kt}$$

where:

$e$  is the base of the natural logarithm;

$c$  is a constant at  $y_0$  (initial concentration) at  $t = 0$ , and;

$-kt$  is a constant for the predicted time, with the minus sign representing decay of concentration with time.

A trend line and the equation for that trend line are generated for the data set based on known x-values for the best-fit curve. The y intercept for the regression trendline is set at zero. This is appropriate, based on the assumed absence of manganese, molybdenum and vanadium concentrations in background ground water quality data.

### 6.2.2 Results of Trendline Analysis

Results of the trendline analysis are presented on the Figures in Appendix B. It is possible that future ground water concentration trends may differ from results generated using the two data sets, or that future trends may fall in between the predictions based on each data set. The minimum range of each graph has been set at the respective RBC. Analysis of the forecast trends suggests the following from the November 1997 to October 2009 data set:

- Monitor wells that appear somewhat uncertain to reach the RBC following LSE include wells KM-2, KM-3 and KM-4 that surround the former scrubber pond, and wells KM-6, KM-8, KM-15 and KM-16 that are south and downgradient of the covered S-X pond basin and the site.
- Wells KM-5 and KM-9 were reduced to the RBC for molybdenum in 2003 as predicted by use of these trendlines. However, a spike in molybdenum in the ground water between 2003 and 2007 affected both wells. Both well KM-5 and KM-9 results in October 2009 indicate that the molybdenum concentrations are below the RBC.
- Molybdenum concentrations will continue to decline in most wells in response to LSE and reclamation. However, wells downgradient of the former S-X and scrubber pond will have molybdenum concentrations exceeding the RBC well into the future.
- On-site wells and several off-site wells are forecast to exceed the vanadium RBC for a period of twenty years or greater following remedial actions completed in 1997. Based on current trends, wells KM-9 and KM-13 are the first wells expected to fall below the vanadium RBC. Monitor wells located downgradient of the former S-X and scrubber pond will have vanadium concentrations exceeding the RBC far beyond 2020 based on current trends.
- Manganese is estimated to potentially exceed the RBC for more than 40 years following LSE in well KM-8, in part as the result of a rising manganese trend since 2004. Well KM-3 will exceed the manganese RBC for an uncertain period because a decreasing trend can not be predicted from the data. The rising manganese trend

in well KM-3 is not occurring in other wells monitoring the covered scrubber pond area.

## **7.0 CONCLUSIONS**

Prior to 1997, Tronox discontinued discharges from unlined ponds to ground water. Analysis of real-time monitoring ground water data indicates that remediation efforts of the ponds prior to and during 1997 resulted in notable ground water quality improvement at most of the on-site, POC, and off-site well locations. Predicted trends (water quality projections based on real-time monitoring) suggest that five well locations currently exceeding the RBC have the potential to drop below the RBC for molybdenum within 20 years following LSE. Only two wells have ground water concentrations that will fall below the RBC for vanadium within this time period. A group of wells indicate uncertainty in reasonably achieving the RBC including wells that surround the former scrubber pond and wells that monitor ground water to the south and downgradient of the covered S-X pond basin and the site.

Based on a review of water quality through October 2009, recent water quality trends, and predictions of future concentrations, the following conclusions are drawn.

### **On-site Water Quality Conclusions**

- The largest continued impacts to ground water noted on the site occur immediately downgradient of the former scrubber and S-X pond basins.
- Generally, concentrations of common ions and TDS have decreased with time in the on-site wells. This trend has flattened somewhat between 2000 and the present for a number of the on-site wells near the west side of the facility as these concentrations approach background.
- Increased or spiked concentrations at several wells between 2004 and 2006 may be related to rising water levels in the aquifer following years of drought or potentially be the result of increased infiltration though unmitigated on-site sources. Seasonal concentration trends noted in some well locations, including KM-6 and KM-8 also appear to be correlated with changes in water levels.
- A rising nitrate trend is noted at a number of well locations near the covered S-X pond. Nitrate plus nitrite concentrations have doubled in well KM-8 between 2001

and 2009. Increasing nitrate plus nitrite is also noted in shallow well KM-4 west of the calcine cap and the covered scrubber pond.

- Vanadium and molybdenum continue to exceed the RBC at most of the on-site POC wells and non-POC wells, except wells KM-5 and KM-9 that are below the molybdenum RBC.
- A decreased pH in the ground water between 1999 and 2001 may have caused increased metals concentrations in some POC wells during that period. The pH is now slightly less than neutral across the site and at off-site locations, with the lowest pH areas identified around the former S-X pond.
- Concentrations of TBP and TPH exceed the RBC in well KM-8 ground water. TPH indicates a decreasing ground water trend through 2005 with only seasonal changes noted to the present. TBP indicates an overall decreasing trend since LSE was implemented through 2004 with a seasonal fluctuation within this range to the present.
- Concentrations of arsenic in ground water are found above the RBC in the wells monitoring the scrubber ponds and in one well (KM-8) near former S-X pond. Arsenic is identified at small concentration in shallow ground water in both on and off site wells not located near these sources.
- Manganese decreased with time in nearly all wells following LSE and the remedial actions completed in 1997. Manganese concentrations are found above the RBC in two wells monitoring the former S-X and scrubber ponds. Well KM-3 indicates an increasing manganese trend following implementation of LSE. Well KM-8 manganese concentrations are seasonal. Concentrations decreased substantially between 1997 and 2004, but currently are increasing and remain an order of magnitude above the RBC.
- On-site deep well KM-19 was below the RBC for all COC in 2009.
- Predicted ground water concentrations for molybdenum and vanadium in the wells monitoring the former S-X and scrubber ponds indicate these COC will exceed the RBC for 20 or more years following LSE. This period of time is longer than modeling estimates for LSE.

### **Off-Site Ground and Surface Water Quality Conclusions**

- Generally, common ions and TDS decreased with time in the off-site wells.

- Increasing concentrations for several constituents in well KM-16 following 2004 appear related to rising water levels in the aquifer following years of drought or an increase in precipitation, or both.
- Ground water concentrations of common ions and TDS decreased in well KM-17 since peaking in 1998. Molybdenum concentrations indicate a decreasing trend in this well. Vanadium concentrations in well KM-17 are less than the RBC and near the detection limit.
- Vanadium and molybdenum concentrations in ground water continue to exceed the RBC in most of the off-site wells. Molybdenum concentrations continued to decrease through 2009, with a spike in concentration noted in 2006. Vanadium concentrations are also decreasing in KM-15, KM-16 and KM-18, although vanadium increased in KM-16 between 2004 and 2006.
- Arsenic in the ground water is near the method detection limit and below RBC at all off-site well locations.
- Manganese continues to decrease at off-site locations and is less than the RBC at all off-site locations.
- Finch and Big Spring are below the RBC for molybdenum. Both locations continue to indicate decreasing trends.
- Vanadium concentrations in Finch Spring remain elevated but are less than the RBC and may indicate a decreasing trend. Vanadium is less than the reporting limit in Big Spring.
- Water quality at Upper and Lower Ledger Springs does not appear to be impacted from former site operations based on 2009 water quality results.

### **COC Trendline Predictions**

- Wells KM-5 and KM-9 are less than the molybdenum RBC as predicted with regression analysis.
- Molybdenum is projected to fall below the RBC in three of the downgradient POC wells within ten to fifteen years following LSE. Molybdenum concentrations will continue to exceed the RBC at the on-site wells monitoring the former S-X and scrubber ponds (KM-2, KM-3, KM-4, KM-6 and KM-8) for considerably longer based on increased concentrations noted during the past 5-year period.
- The concentration of vanadium in the ground water is projected exceed the RBC in most on-site POC wells and off-site wells for a considerably longer period than

molybdenum. Wells KM-9 and KM-13 are predicted to be near the vanadium RBC within about 15 to 20 years following LSE. Vanadium ground water concentrations will continue to exceed the RBC at the on-site wells monitoring the former S-X and scrubber ponds (KM-2, KM-3, KM-4, KM-6 and KM-8) for considerably longer based on increased or flattening concentrations noted during the past 5-year period.

- As a result of overall larger concentrations and unclear trends for arsenic and vanadium, well KM-8 continues to lag other wells in concentration decreases. Therefore, KM-8 will take considerably longer to fall below the RBCs for manganese, molybdenum and vanadium.

## **8.0 RECOMMENDATIONS**

Ground and surface water monitoring will continue at the Tronox facility on a semiannual basis to assess the effects of remedial changes made at the site as required in the ROD. Field data results should be evaluated when sampling occurs to assess current with preceding site conditions.

Parameters that fall below the RBC will be evaluated and reported to EPA when these occur. All sampling and analytical results should be reviewed semiannually in accordance with the protocols contained in SW846 and EPA laboratory data validation functional guidelines to assess the quality of the data results. Ground and surface water quality will be appended semiannually to the RD/RA database. Results of the data review will be transmitted to EPA and IDEQ.

All ground water quality trends and predicted water quality should be evaluated in an annual report to assess the improvements to ground and surface water quality. Future annual evaluations will include the incorporation of ground water monitoring data from the Evergreen facility. This facility monitors ground water downgradient of the Tronox property on industrial property owned by the City of Soda Springs. Evaluation of Evergreen data in conjunction with Tronox ground and surface water data will provide an increased understanding of ground water flow paths downgradient of the Tronox site.



## 9.0 REFERENCES

Dames & Moore, 1991a, RI/FS Work Plan for Soda Springs, Idaho Facility, Kerr-McGee Chemical Company, August 1991.

Dames & Moore, 1991b, Candidate Technology Memorandum, Kerr-McGee Chemical Corporation (KMCC) Soda Springs RI/FS, September 3, 1991.

Dames & Moore, 1992b, Revised May 1992 Sample Plan, Preliminary Site Characterization, Kerr-McGee Soda Springs Facility, Idaho, for Kerr-McGee Chemical Corporation, May 5, 1992.

Dames & Moore, 1995, Final Remedial Investigation Report for the Kerr-McGee Chemical Corporation, Soda Springs, Idaho, April 1995.

Dames & Moore, 1995a, Draft Comparative Analysis Report, Soda Springs, Idaho Facility, Revised Draft Ground Water Modeling Report, February 1995.

Drever, J.I., 1988, The Geochemistry of Natural Waters, 2nd Edition: Prentice Hall Inc., Englewood Cliffs, New Jersey, 437 pp.

Global Environmental Technologies, LLC, 1999, Draft Remedial Action Completion Report for Kerr-McGee Chemical LLC, Soda Springs, Idaho, March 1999.

Global Environmental Technologies, LLC, 2002, Draft Remedial Action Completion Report, Calcine Capping 2000-2001 for Kerr-McGee Chemical LLC, Soda Springs, Idaho, February 2002.

Global Environmental Technologies, LLC, 2009, May 2009 Data Validation Report and Updated Remedial Design/Remedial Action (RD/RA) Database, November 29, 2009.

Global Environmental Technologies, LLC, 2009, October 2009 Data Validation Report and Updated Remedial Design/Remedial Action (RD/RA) Database, February 9, 2010.

Golder Associates, 1985 Report on Hydrogeological Investigation, Soda Springs Plant Site, Soda Springs, Idaho, Volumes 1, 2, and 3, prepared for the Monsanto Industrial Chemical Company, November 1985.

Golder Associates, 1992a, Phase I Remedial Investigation/Feasibility Study, Preliminary Site Characterization Summary Report for the Soda Springs Elemental Phosphorus Plant.

Hem, J. D., 1978, Study and Interpretation of the Chemical Characteristics of Natural Water: U.S. Geological Survey Water-Supply Paper 1473, 363 pp.

Isherwood, D.K., 1981, Geoscience Data Base Handbook for Modeling a Nuclear Waste Repository: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards Publication, NUREG/CR-0912, v. 2, 331 pp.

Lewis, B.D., and Goldstein, F.J., 1982, Evaluation of a Predictive Ground-Water Solute-Transport Model at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water Resources Investigations 82-25.

Nace, R.L., Stewart, J.W., Walton, W.C., Barraclough, J.T., Peckham, A.E., Theis, C.V., Johnson, A.I., and McQueen, I.S., 1959, Geography, Geology, and Water Resources of the National Reactor Testing Station, Idaho, Part 3, Hydrology and Water Resources: U.S. Atomic Energy Commission, Idaho Operations Office Publication, IDO-22034-USGS.

Piper, A.M., 1944, A Graphic Procedure in the Geochemical Interpretation of Water Analyses; American Geophysical Union Transactions, v.25, p. 914-923.

Robertson, J.B., 1974, Digital Modeling of Radioactive and Chemical Waste Transport in the Snake River Plain Aquifer at the National Reactor Testing Station, Idaho: U.S. Geological Survey Open-File Report 76-717.

U.S. Environmental Protection Agency, 1994, Draft Human Health and Ecological Risk Assessments for Kerr-McGee Chemical Corporation, Soda Springs, Idaho, October 1993.

U.S. Environmental Protection Agency, 1994, USEPA Contract Laboratory Program National Functional Guidelines for organic and inorganic Data Review, EPA540/R-94/012, February 1994 and December 1994.

U.S. Department of Health and Human Services, Public Health Service, 1990, Draft Toxicological Profile for Vanadium: U.S.H.H.S Public Health Service, Agency for Toxic Substances and Disease Registry.

## **TABLES**

TABLE 1-1  
MONITOR WELL CONSTRUCTION AND WELL TESTING RESULTS

Well Designation	Completed Date	Northing	Easting	Elevation Top of PVC <u>Feet msl</u>	Elevation Concrete Pad <u>Feet</u>	Top of Screen	Bottom of Screen	Hydraulic Conductivity (ft/day)	Unit Monitored	Lithology Screened Interval
KM-1	10/07/91	373073.394	659740.078	6029.72	6027.50	45.9	55.9	204	I4	clay, tuff
KM-2	09/21/91	371777.028	660379.196	6025.11	6023.00	47.2	57.2	266	Qb5	basalt, clay
KM-3	10/11/91	371745.657	659825.555	6014.28	6012.20	39.1	49.1	91	I4	clay, tuff
KM-4	10/02/91	372033.826	659695.190	6023.44	6021.90	43.7	53.7	153	I4	cinders, tuff
KM-5	10/01/91	372710.706	658856.602	6002.72	6001.50	38	48	37	Qb5	vesicular basalt
KM-6	09/24/91	371736.929	658601.626	5988.13	5986.00	34.7	44.7	340	Qb5	vesicular basalt
KM-7	09/26/91	372113.189	658578.407	6001.63	5999.90	46.2	56.2	na	Qb5/I4	vesicular basalt and cinders
KM-8	10/21/91	371771.964	658144.161	5976.75	5974.40	34.6	44.6	9.4	Qb5	basalt, clay
KM-9	09/29/91	371770.477	657836.280	5973.56	5971.50	47.5	57.5	48	Qb5	vesicular basalt
KM-10	10/12/91	373073.856	659761.715	6029.43	6027.90	100	120	na	Qb3	basalt
KM-11	10/29/91	371745.582	659847.119	6013.63	6012.10	80	100	96	Qb3	basalt
KM-12	10/29/91	371778.391	658119.553	5976.07	5973.90	134.1	154.1	34	Qb3	basalt
KM-13	10/07/91	372185.749	658042.505	5977.65	5975.60	46.4	56.4	17	Qb5	basalt
KM-15	09/24/92	370332.04	657491.89	5958.10	5956.20	45.2	55.2	105	Qb5a/I5	cinders, basalt
KM-16	09/18/92	371058.74	658151.12	5998.97	5997.20	63.3	73.3	97	Qb5	basalt
KM-17	09/25/92	371100.35	659365.30	6001.11	5999.60	38.2	48.2	2.3	Qb4/I3	basalt, silt
KM-18	10/03/92	370336.14	657468.67	5958.25	5956.80	152.6	172.6	8.2	Qb3	basalt
KM-19	10/15/92	371788.11	658085.74	5975.17	5973.80	193.6	213.6	15	Qb2/I1	fractured basalt, clay

**TABLE 1-2**  
**MAXIMUM CONCENTRATIONS OF COC AND MOST CURRENT CONCENTRATIONS**  
**IN TRONOX WELLS AND OFF-SITE SPRINGS**

Well Designation	Arsenic Concentrations		Manganese Concentrations		Molybdenum Concentrations		Total Petroleum Hydrocarbons Concentrations		Tributyl Phosphate Concentrations		Vanadium Concentrations	
	RBC = 10 ug/l		RBC = 180 ug/l		RBC = 180 ug/l		RBC = 0.73 mg/l		RBC = 180 ug/l		RBC = 260 ug/l	
	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)	Largest (mg/l)	Most Current (mg/l)	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)
KM-2*	53	12	444	28	11800	980	2.0	NA	7	NA	15500	4300
KM-3*	27	9.4	1680	610	44900	5700	1.8	NA	1400	NA	13200	2100
KM-4	63	8.1	1160	92	15300	1200	NA	NA	NA	NA	23300	4500
KM-5*	12.2	2.3	399	3.8	1460	170	NA	NA	3	NA	15800	1000
KM-6	6.5	4.6	291	160	2140	1100	2.0	NA	110	NA	6630	3800
KM-7	6.9	4.6	197	110	593	390	2.0	NA	NA	NA	3410	2600
KM-8*	170	84	8770	6500	165000	41000	9.5	1.1	4442	80	29000	16000
KM-9*	5	1.3	113	7.1	1740	150	NA	NA	ND	NA	3590	410
KM-11*	2	ND	157	16	5600	230	0.42	NA	112	NA	492	9.4
KM-12*	23	1.4	177	22	9290	380	0.39	NA	13	NA	5580	550
KM-13*	4	1.3	131	8.8	6790	250	0.18	NA	12	NA	6420	460
KM-15	5.6	1.8	543	49	6950	390	0.15	NA	484	NA	3840	820
KM-16	7.3	3.3	364	97	2300	690	1.9	NA	180	NA	4250	2200
KM-17	1.5	0.23	84	1.5	987	370	1.2	NA	170	NA	493	4.4
KM-18	3.7	1.5	332	37	6340	360	1.3	NA	410	NA	2990	610
KM-19*	2	0.51	32.3	1.4	258	16	1.1	NA	4	NA	558	120
Big Spring	1.1	0.56	1.8	0.6	508	160	NA	NA	NA	NA	13.6	3.2
Finch Spring	2	0.43	4.4	0.34	663	150	0.22	NA	ND	NA	91.7	45
Upper Ledger	3.7	ND	2.6	0.76	22.4	ND	NA	NA	NA	NA	5.1	1.4
Lower Ledger	4.2	ND	1.5	ND	54.1	ND	NA	NA	NA	NA	14.9	1.7

Footnotes:

\* = Point of Compliance Well

NA = Not Available – not sampled during May 2009

ND = Not Detected (less than IDL)

Shaded cells indicate exceedence of RBC

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/  
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-1 (shallow well paired with KM-10)	Lateral gradient background well	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, No organics	No	None	Background sampling not needed; relying on RBC performance standards at POC wells and no statistical background comparison
KM-2 (shallow well)	Active calcine tailing impoundment/former scrubber pond area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, although not truly downgradient of calcine or former scrubber pond; monitor changes in ground water concentrations in conjunction with changes at active calcine impoundment area and scrubber pond closure
KM-3 (shallow well paired with KM-11)	Reclaimed scrubber pond	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3,4 total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Point of compliance well; monitor changes in ground concentrations water along southern boundary in conjunction with scrubber pond closure
KM-4 (shallow well)	Active calcine tailing impoundment area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1, 3, total chromatographable organics Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Will provide monitoring of calcine impoundment following capping. Not a POC well

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/  
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-5 (shallow well)	Historic scrubber pond/historic MAP ponds, Boiler blowdown pond/downgradient of facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, monitors downgradient of northern and central areas of entire plant facility; no active or historic activities downgradient of this location
KM-6 (shallow well)	Historic limestone Settling ponds	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Rounds 1, 3	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Monitors zone of increased transmissivity on the southern boundary of facility; not a POC well
KM-7 (shallow well)	Historic calcine impoundment area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	No	None	Yes (2000-->)	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Monitors central portion of the facility and provides additional justification for contouring of COC; not a POC well
KM-8 (shallow well paired with KM-12 and KM-19)	Former S-X pond/downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, metals, radionuclides Rounds 1, 4, total chromatograph-able organics Round 1,3, TPH and semivolts Rounds 4 and 8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/  
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-9 (shallow well)	Former S-X pond/downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, downgradient of entire facility; comparisons can be made with ground water model results to track and evaluate performance
KM-10 (intermediate well, paired with KM-1)	Intermediate depth background well	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	No	None	Background sampling not needed; relying on RBC performance standards at POC wells and no statistical background comparison
KM-11 (intermediate well, paired with KM-3)	Former scrubber pond	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with scrubber pond closure
KM-12 (intermediate well paired with KM-8, KM-19)	Former S-X pond/downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Round 1, total chromatographable organics Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure
KM-13 (shallow well)	Former S-X pond (north end) and downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Round 1, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Point of compliance well, downgradient of entire facility



TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/  
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-15 (shallow well, paired with KM-18)	Off-site well southwest of former S-X pond and within main area of impacted ground water	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Located in off-site area near modeled point; current RBC exceedences of , Mo, and V
KM-16 (shallow well)	Off-site well south of former S-X and settling ponds	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Located off-site and laterally downgradient of the site; RBC exceedences of Mo, and V
KM-17 (shallow well)	Off-site well southwest of former scrubber pond and active calcine tailing	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Located off-site and laterally downgradient of the site; RBC exceedences of Mo
KM-18 (intermediate well, paired with KM-15)	Off-site well southwest of former S-X pond, pond and within main area of impacted ground water, paired with KM-15	Not completed prior to Round 5	Long-list metals, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitors deeper aquifer zone for ground water impact; current RBC exceedences Mo, and V
KM-19 (deep well paired with KM-8 and KM-12)	Former S-X pond and downgradient of plant facility	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Round 5	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/  
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
Finch Spring (spring discharging from base of Finch Fault to surface water)	Spring south of facility which has appeared to be impacted primarily from scrubber discharge	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, long-list metals, semivolts and TPH Round 5	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor downgradient changes to ground water from scrubber pond closure and other remedial actions on-site, current RBC exceedence of Mo
Big Spring (spring discharging to surface water flowing to Bear River)	Spring south of Soda Springs, furthest south discharge identified from Bear River Basin to Bear River	Not sampled prior to Round 6	Short-list metals	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Current exceedence of Mo RBC, too far from plant to measure direct changes associated with remedial actions; other influencing factor contributing to ground water upgradient of site and downgradient of KMCC, will continue to monitor
Upper Ledge(r) Spring (spring discharging from Ledger Creek drainage, between Kelley Park and Rabbit Mountain	An important source of drinking water for the town of Soda Springs. EPA requested additional monitoring of this spring by KMC LLC following public meeting and on amended ROD comments in June 2000.	1 Event (no impacts noted)	Long-list metals Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor ground water quality

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/  
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
Lower Ledge(r) Spring (spring discharging from Ledger Creek drainage, between Kelley Park and Rabbit Mountain)	An important source of drinking water for the town of Soda Springs. EPA requested additional monitoring of this spring by KMC LLC following public meeting and on amended ROD comments in June 2000.	1 Event (no impacts noted)	Long-list metals Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor ground water quality

**TABLE 5-1**  
**CHRONOLOGY OF PROCESS CHANGES**

Event	Date(s)	Comments
S-X stream diverted from the S-X pond to the scrubber pond	1992 through 1993	Flow may have been diverted between ponds during this time period.
MAP ponds taken out of service; third roaster taken off-line in April	1993	Ponds reclaimed. Effects of remediation apparent in well KM-5.
S-X pond receiving discharge from S-X circuit	1994	S-X circuit discharge diverted to S-X pond for last time.
S-X stream diverted from the S-X pond to the scrubber pond	Late 1994 to mid 1995	S-X pond contained residual process water during 1995
S-X stream diverted to newly-constructed lined ponds	Mid 1995	Precipitation continued to fill the S-X pond basin and infiltrate. Pond contained significant volume of precipitation during 1996-1997 winter.
Scrubber pond taken out of service	April 1997	Scrubber pond pumped to the calcine pond. Some scrubber stream sent to calcine ponds. Residual liquid in pond and meteoric water drained out during stabilization of the pond sediments. All baghouses on-line in October.
Discontinue sluicing calcine	April – October 1997	Calcine dewatered, and residual water recycled in process. Dewatered calcine stockpiled north of the calcine impoundment.
Fertilizer Plant Operational	July 1998 to May 2000	Calcine removed from active calcine Impoundment, processed to fertilizer. Reject fertilizer placed in calcine impoundment.
Discontinue Vanadium Processing – Vanadium Plant Idle	January 1999 to present	Discontinue stockpiling of calcine, discontinue all vanadium process streams to lined ponds, discontinue the recycle of roaster reject.
Cap Active Calcine Impoundment	May 2001 through August 2001	Calcine was capped using multi-component cover to eliminate meteoric infiltration through calcine tailing. Substantial amount of dust control/construction water used.
Dismantle Vanadium Plant	November 2001 through May 2002	Materials removed to approved facility, surface footprint cleaned in preparation for surface regrade. Footprint regraded with limestone fines in April/May 2003
Dismantle Fertilizer Plant	November 2002 through June 2003	Materials removed to approved facility, surface footprint cleaned in preparation for surface regrade.
Reclaim Stormwater Runoff Ponds	September through October 2003	Solids and liquids removed to 10-acre pond, site regraded and reclaimed.
Reclaim 5-Acre Ponds	September through October 2004	Solids and liquids removed to 10-acre pond, east pond site regraded and reclaimed.
Regrade Scrubber Pond Cover	November 2005	Fill and regrade south of calcine cap

**Note:** Changes in the discharge locations of both the S-X and scrubber streams affected concentrations in both on-site and off-site wells and Finch Spring during operation.

TABLE 6-1  
PROJECTED COC TRENDS  
BASED ON NOVEMBER 1997 THROUGH OCTOBER 2009 DATA

Monitor Well	MANGANESE				MOLYBDENUM				VANADIUM			
	October 2009 Conc. (ug/l)	Projected Year Below RBC	Regression Equation	Regression Coefficient	October 2009 Conc. (ug/l)	Projected Year Below RBC	Regression Equation	Regression Coefficient	October 2009 Conc. (ug/l)	Projected Year Below RBC	Regression Equation	Regression Coefficient
KM-2*	28	Below RBC			980	2021	$y = 1E+09e-0.0106x$	$R^2 = 0.7098$	4300	2042	$y = 2E+07e-0.0065x$	$R^2 = 0.7771$
KM-3*	610	Increasing Trend			5700	2039	$y = 8E+07e-0.0074x$	$R^2 = 0.4848$	2100	2070	$y = 126144e-0.0031x$	$R^2 = 0.1846$
KM-4	92	Below RBC			1200	NE			4500	NE		
KM-5*	3.8	Below RBC			170	Below RBC			1000	2029	$y = 2E+06e-0.0057x$	$R^2 = 0.7516$
KM-6	160	Below RBC			1100	2040	$y = 850039e-0.0051x$	$R^2 = 0.5177$	3800	2092	$y = 125619e-0.0027x$	$R^2 = 0.341$
KM-7	110	Below RBC			390	NE			2600	NE		
KM-8*	6500	>2050	$y = 124238e-0.0029x$	$R^2 = 0.0731$	41000	2049	$y = 9E+08e-0.0079x$	$R^2 = 0.6953$	16000	Increasing Trend	$y = 92.824e0.0042x$	$R^2 = 0.1963$
KM-9*	7.1	Below RBC			150	Below RBC			410	2014	$y = 1E+06e-0.0062x$	$R^2 = 0.9344$
KM-11*	16	Below RBC			230	NE			9.4	Below RBC		
KM-12*	22	Below RBC			380	2017	$y = 1E+07e-0.008x$	$R^2 = 0.9389$	550	2022	$y = 530357e-0.0002x$	$R^2 = 0.9519$
KM-13*	8.8	Below RBC			250	2010	$y = 5E+08e-0.0112x$	$R^2 = 0.8188$	460	2018	$y = 189079e-0.0046x$	$R^2 = 0.8927$
KM-15	49	Below RBC			390	2015	$y = 2E+07e-0.0003x$	$R^2 = 0.7713$	820	2029	$y = 342141e-0.0002x$	$R^2 = 0.8656$
KM-16	97	Below RBC			690	2024	$y = 6E+06e-0.0069x$	$R^2 = 0.722$	2200	2049	$y = 589184e-0.0043x$	$R^2 = 0.7835$
KM-17	1.5	Below RBC			370	2029	$y = 31855e-0.0033x$	$R^2 = 0.4046$	4.4	Below RBC		
KM-18	37	Below RBC			360	2015	$y = 2E+07e-0.0082x$	$R^2 = 0.8168$	610	2022	$y = 597097e-0.0053x$	$R^2 = 0.9341$
KM-19*	1.4	Below RBC			16	Below RBC			120	Below RBC		
Finch Spring	0.6	Below RBC			160	Below RBC	$y = 2E+07e-0.0089x$	$R^2 = 0.9435$	3.2	Below RBC		
Big Spring	0.34	Below RBC			150	Below RBC	$y = 555186e-0.0061x$	$R^2 = 0.9251$	45	Below RBC		

SHADED CELL INDICATES CURRENT EXCEEDENCE OF RBC

\* - Indicates Point of Compliance Well

NE - Not evaluated for COC projection

TABLE 6-2  
PROJECTED COC TREND  
BASED ON MAY 2004 THROUGH 2009 DATA

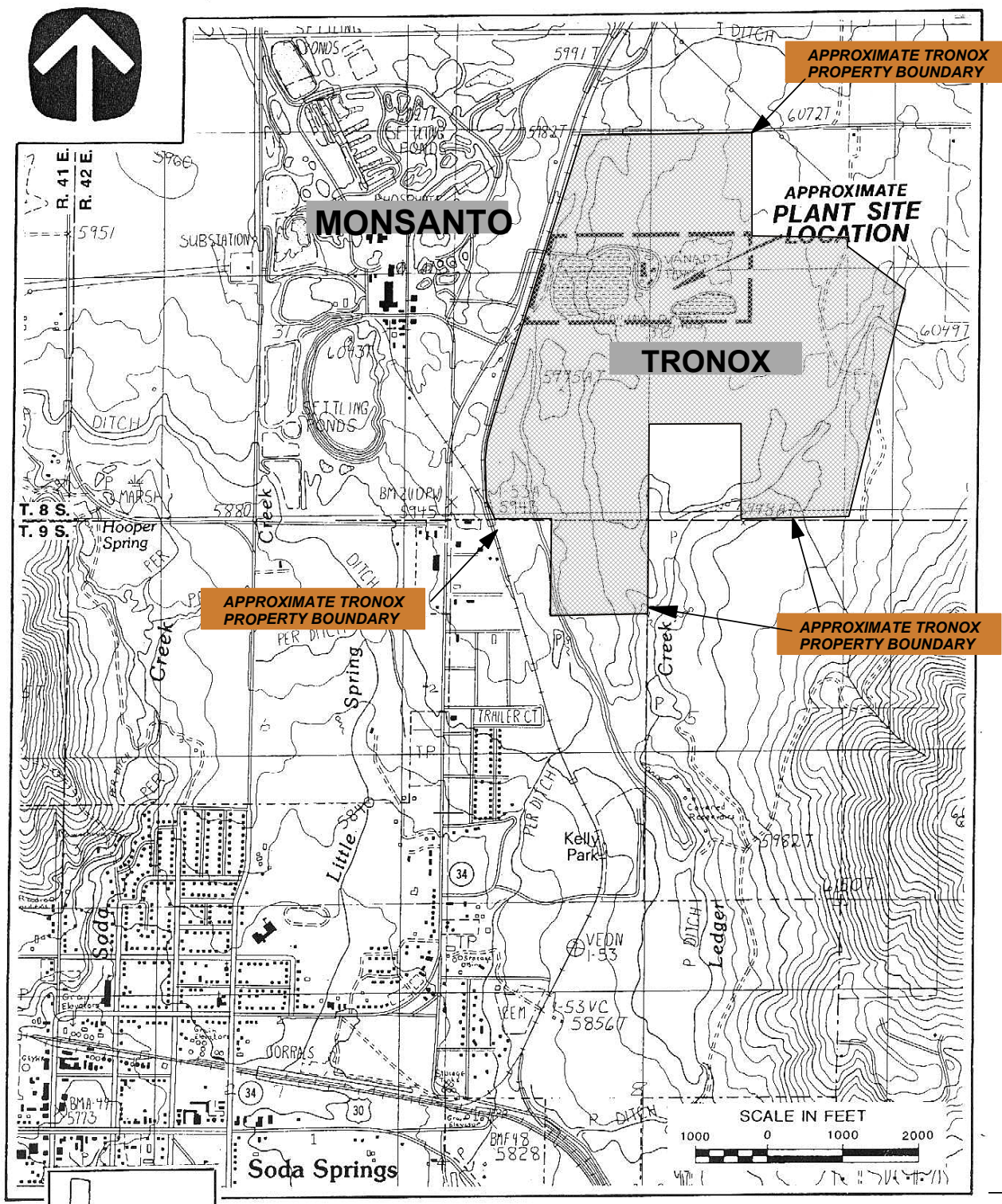
Monitor Well	MOLYBDENUM				VANADIUM			
	October 2009 Conc. (ug/l)	Projected Year Below RBC	Regression Equation	Regression Coefficient	October 2009 Conc. (ug/l)	Projected Year Below RBC	Regression Equation	Regression Coefficient
KM-2*	980	2025	$y = 4E+07e-0.0081x$	R2 = 0.6353	4300	>2050	$y = 8889.5e-0.0005x$	R2 = 0.0154
KM-3*	5700	2080	$y = 1E+06e-0.0042x$	R2 = 0.6095	2100	2043	$y = 2E+06e-0.0051x$	R2 = 0.1239
KM-4	1200	NE			4500	NE		
KM-5*	170	Below RBC			1000	2051	$y = 54186e-0.003x$	R2 = 0.1805
KM-6	1100	>2080	$y = 13269e-0.0018x$	R2 = 0.0548	3800	Increasing Trend	$y = 2489.3e0.0004x$	R2 = 0.0019
KM-7	390	NE			2600	NE		
KM-8*	41000	Increasing Trend	$y = 7118.5e0.0012x$	R2 = 0.0132	16000	>2050	$y = 2E+07e-0.0053x$	R2 = 0.2287
KM-9*	150	Below RBC			410	2019	$y = 49228e-0.0037x$	R2 = 0.5276
KM-11*	230	NE			9.4	Below RBC		
KM-12*	380	2016	$y = 2E+08e-0.0099x$	R2 = 0.976	550	2020	$y = 1E+06e-0.0002x$	R2 = 0.965
KM-13*	250	2013	$y = 690269e-0.0061x$	R2 = 0.3448	460	2025	$y = 24700e-0.003x$	R2 = 0.7544
KM-15	390	2025	$y = 91315e-0.0001x$	R2 = 0.3648	820	2054	$y = 13753e-7E-05x$	R2 = 0.359
KM-16	690	2049	$y = 37671e-0.003x$	R2 = 0.1706	2200	>2080	$y = 27285e-0.0019x$	R2 = 0.1568
KM-17	370	2020	$y = 414027e-0.0054x$	R2 = 0.6173	4.4	Below RBC		
KM-18	360	2020	$y = 332631e-0.0052x$	R2 = 0.4858	610	2027	$y = 128128e-0.0041x$	R2 = 0.7709
KM-19*	16	Below RBC			120	Below RBC		
Finch Spring	160	Below RBC			3.2	Below RBC		
Big Spring	150	Below RBC			45	Below RBC		

SHADED CELL INDICATES EXCEEDENCE OF RBC

\* - Indicates point of compliance wells

NE - Indicates not evaluated for COC projected trend

## FIGURES

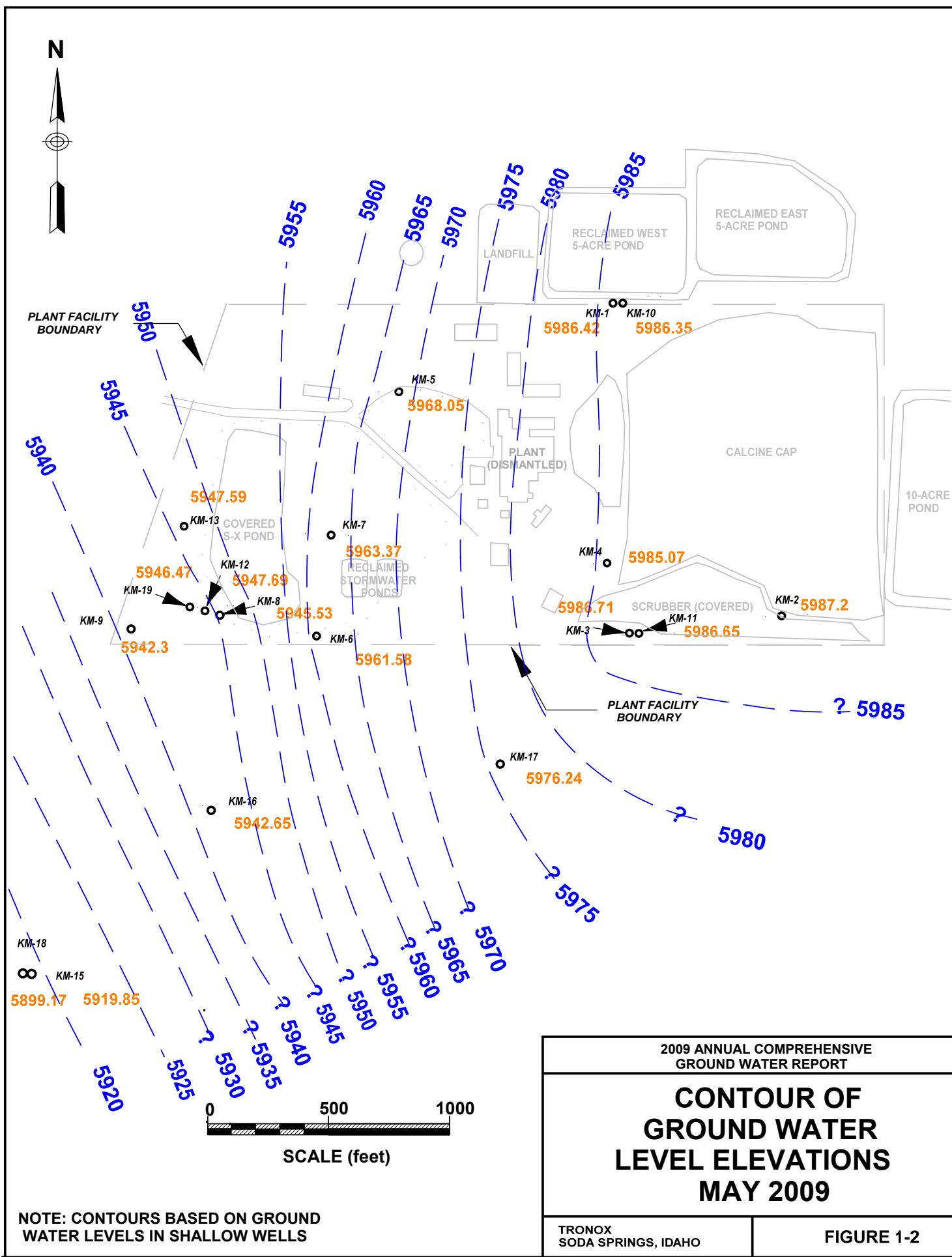


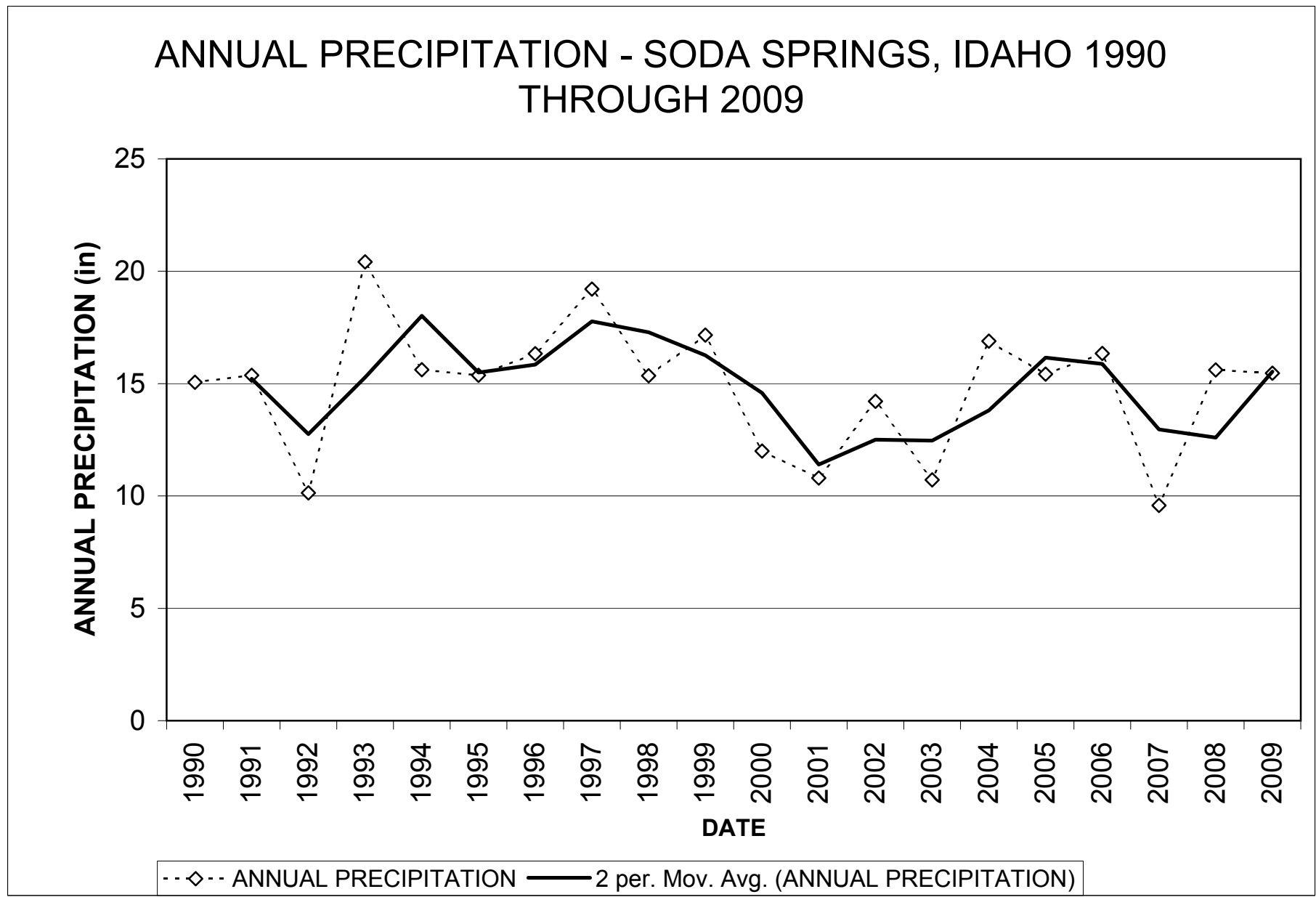
REFERENCE: U.S.G.S. QUADRANGLE  
SODA SPRINGS, IDAHO PROVISIONAL  
EDITION 1982.

## APPROXIMATE TRONOX PROPERTY BOUNDARY LOCATION MAP

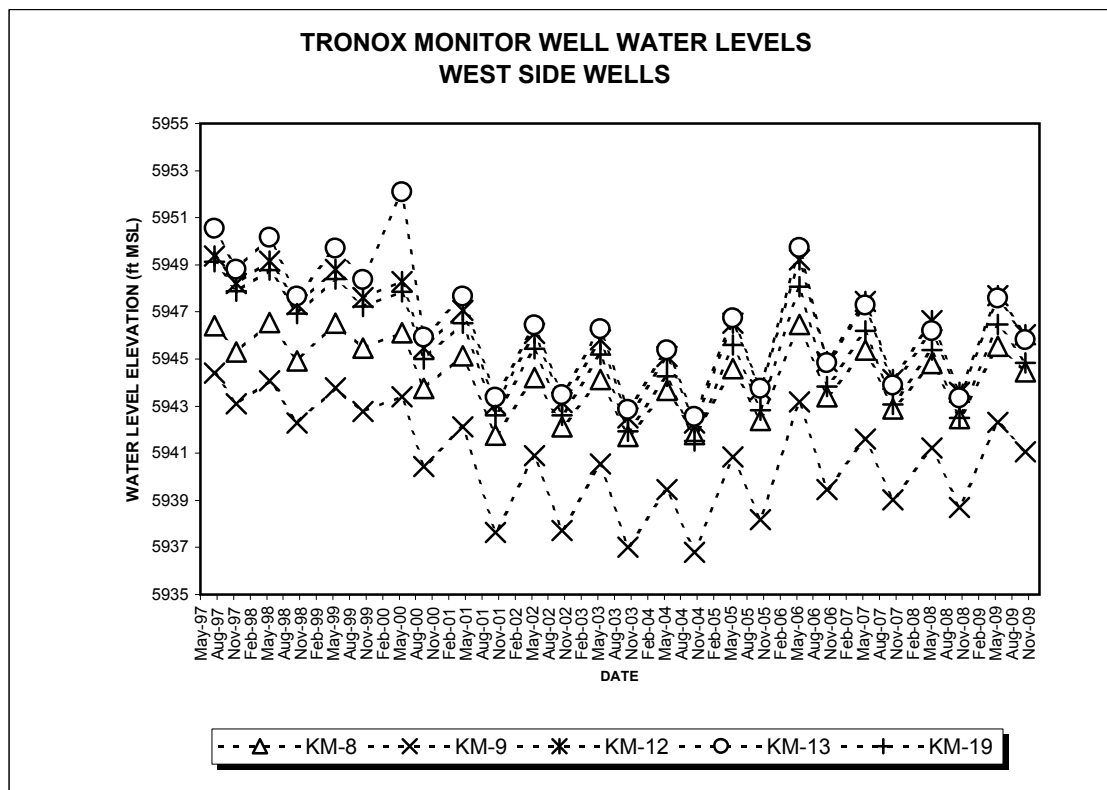
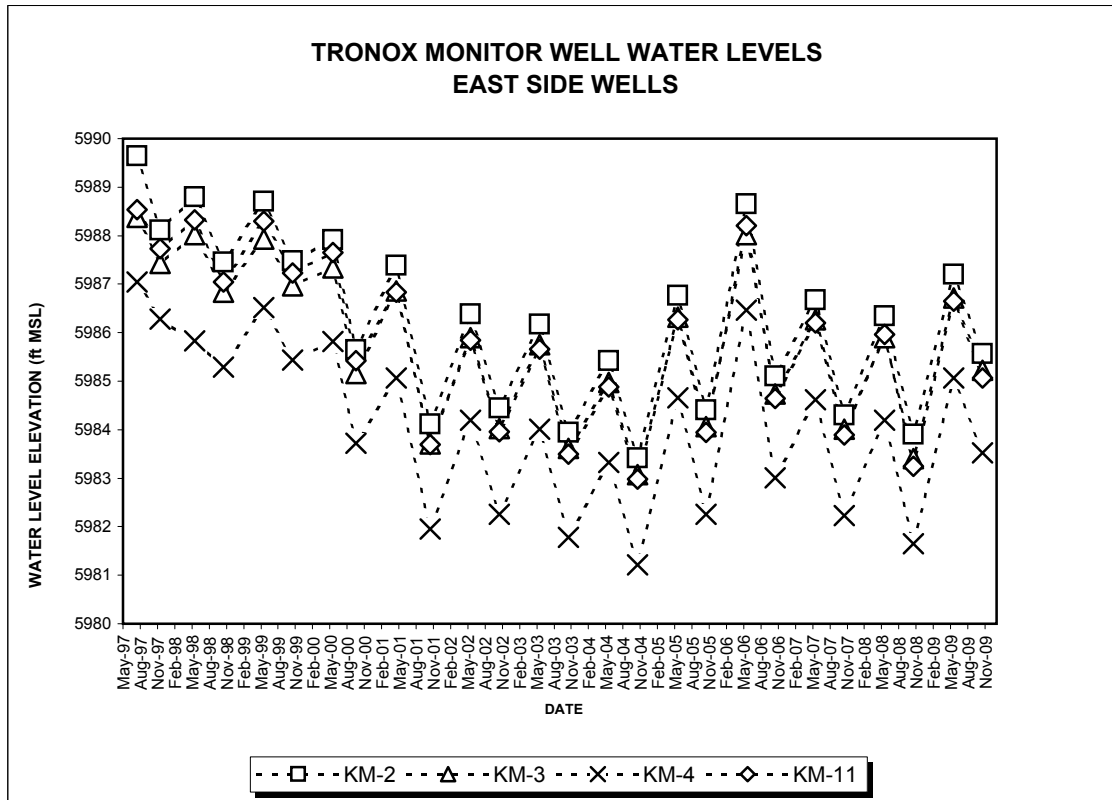
FIGURE 1-1



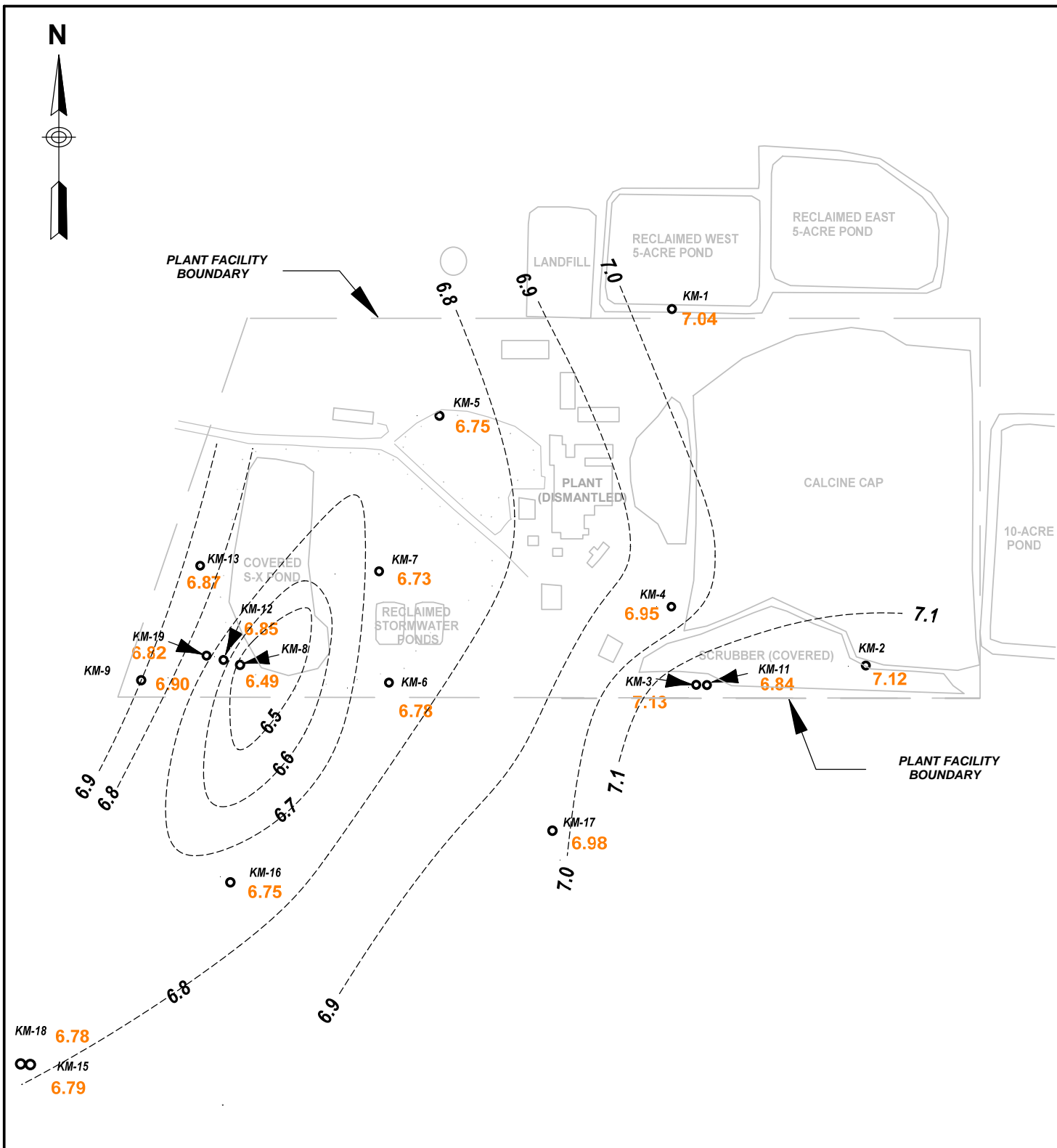




**WATER LEVELS VERSUS TIME  
TRONOX ON-SITE WELLS  
FOLLOWING LSE AND POND RECLAMATION**



**FIGURE 2-2**



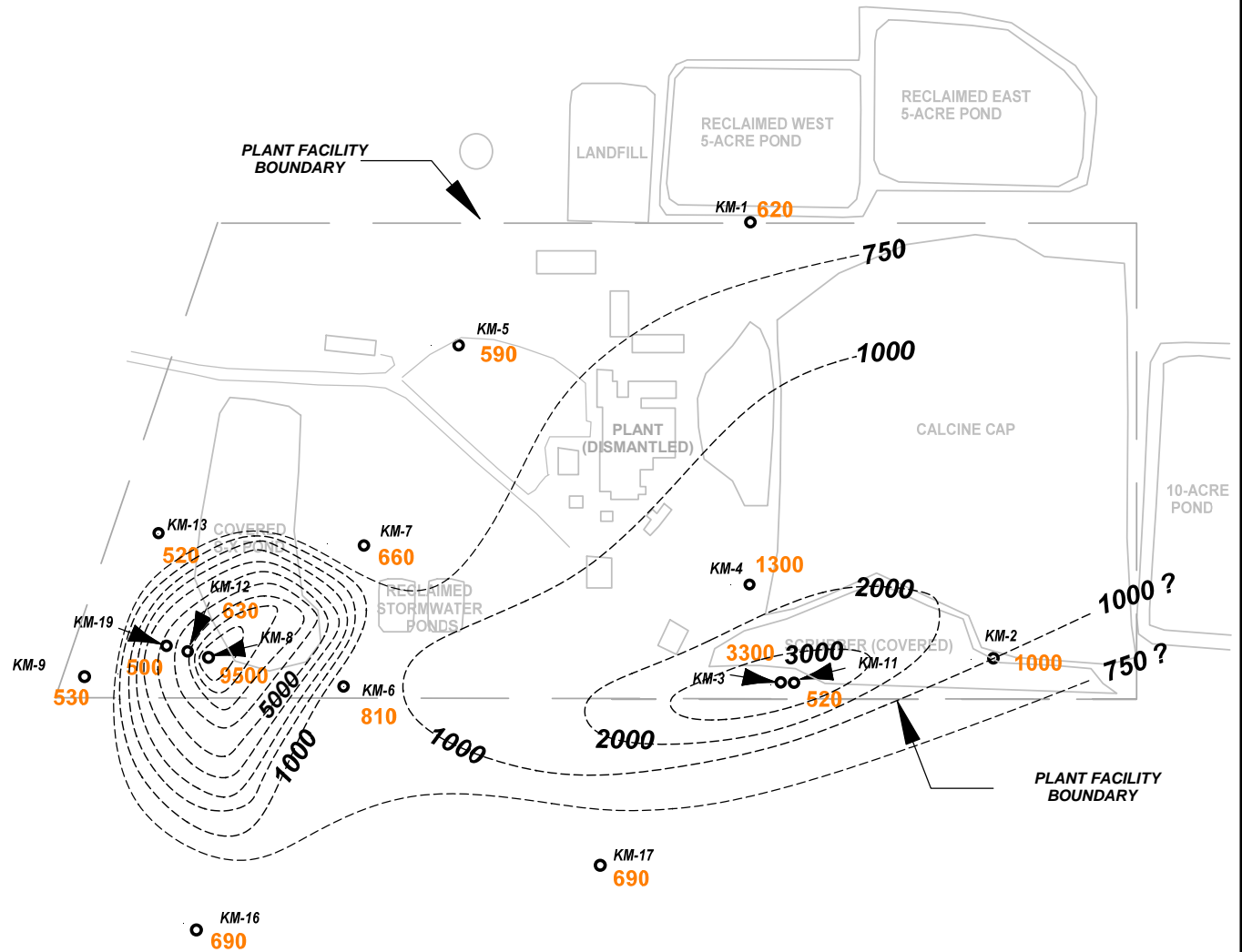
NOTE: CONCENTRATIONS ARE IN pH units.  
CONCENTRATIONS BASED ON OBSERVED CONCENTRATIONS  
IN SHALLOW AQUIFER.

2009 ANNUAL COMPREHENSIVE  
GROUND WATER REPORT

## pH IN GROUND WATER MAY 2009

TRONOX  
SODA SPRINGS, IDAHO

FIGURE 4-1



KM-18  
570  
KM-15  
590



SCALE (feet)

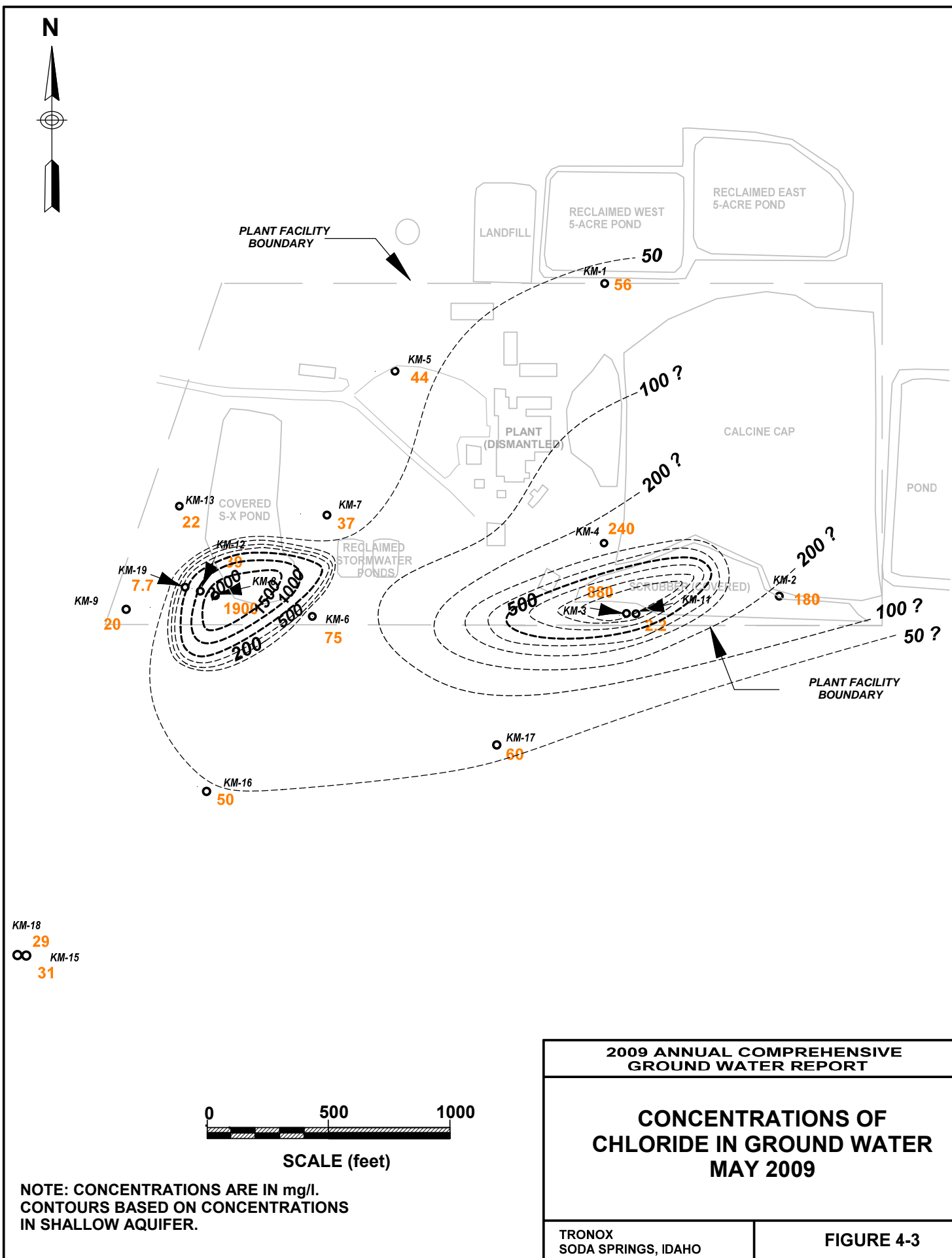
NOTE: CONCENTRATIONS ARE IN mg/l.  
CONTOURS BASED ON CONCENTRATIONS  
IN SHALLOW AQUIFER.

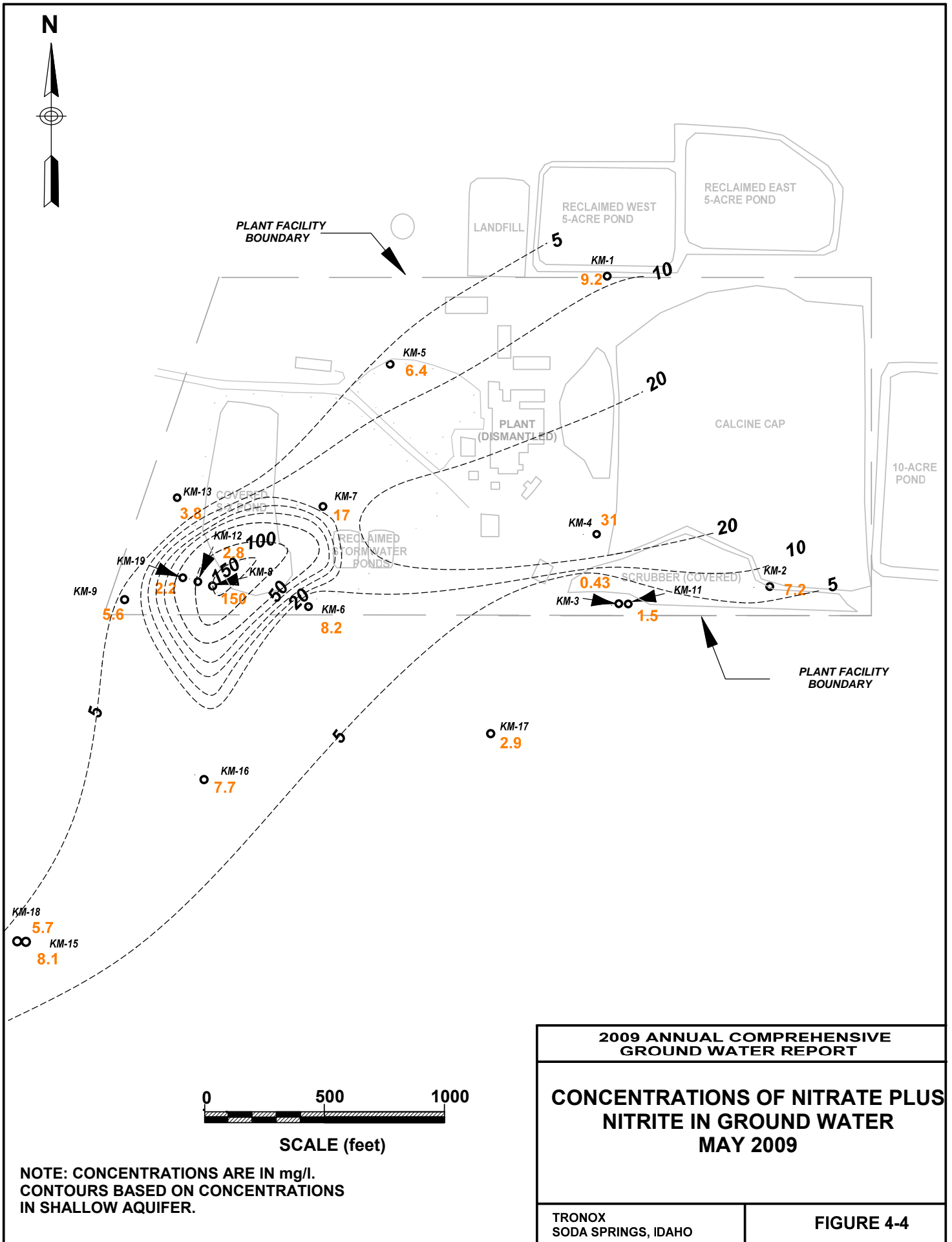
2009 ANNUAL COMPREHENSIVE  
GROUND WATER REPORT

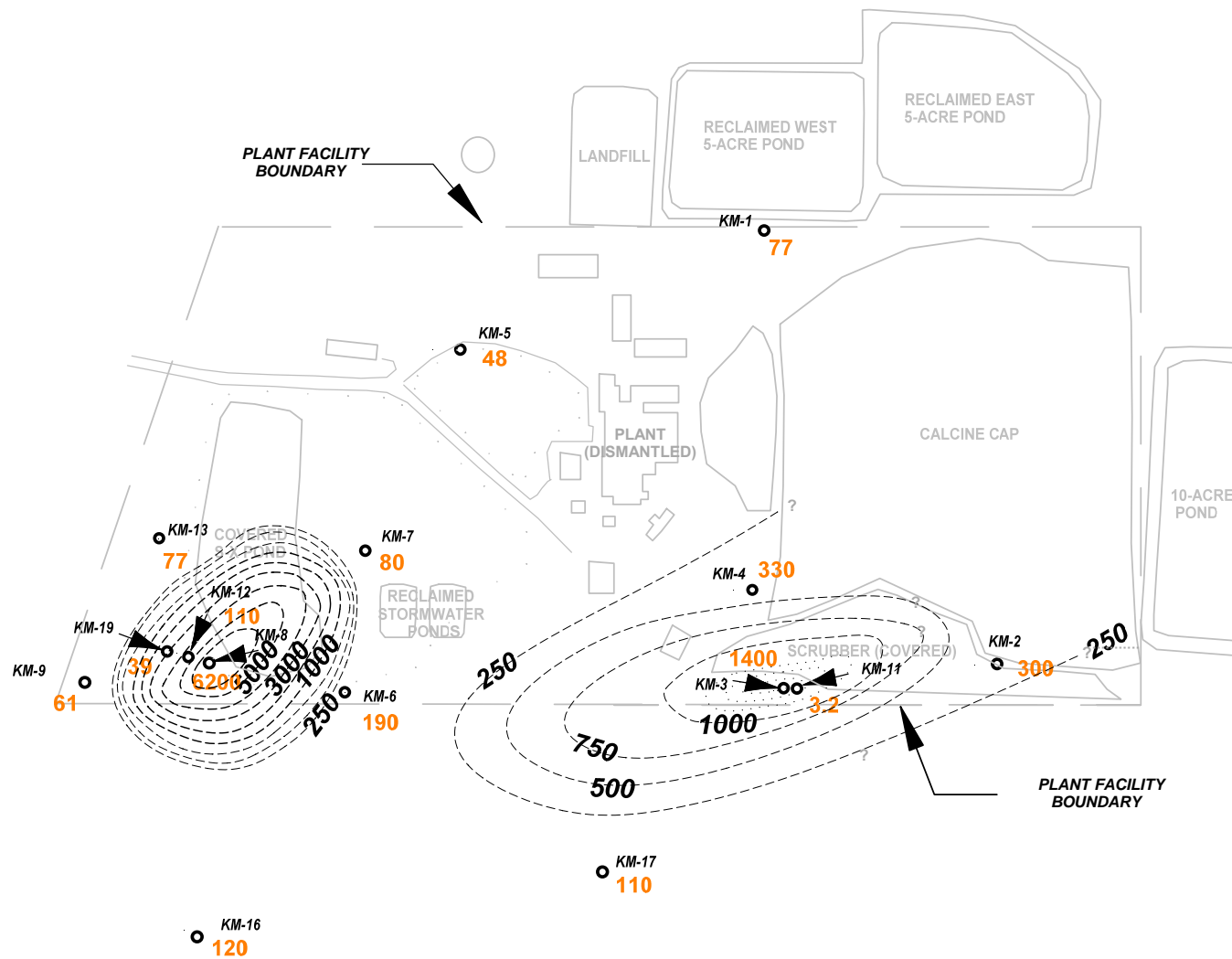
CONCENTRATIONS OF  
TDS IN GROUND WATER  
MAY 2009

TRONOX  
SODA SPRINGS, IDAHO

FIGURE 4-2







KM-18  
93  
KM-15  
98



SCALE (feet)

NOTE: CONCENTRATIONS ARE IN mg/l.  
CONTOURS BASED ON CONCENTRATIONS  
IN SHALLOW AQUIFER.

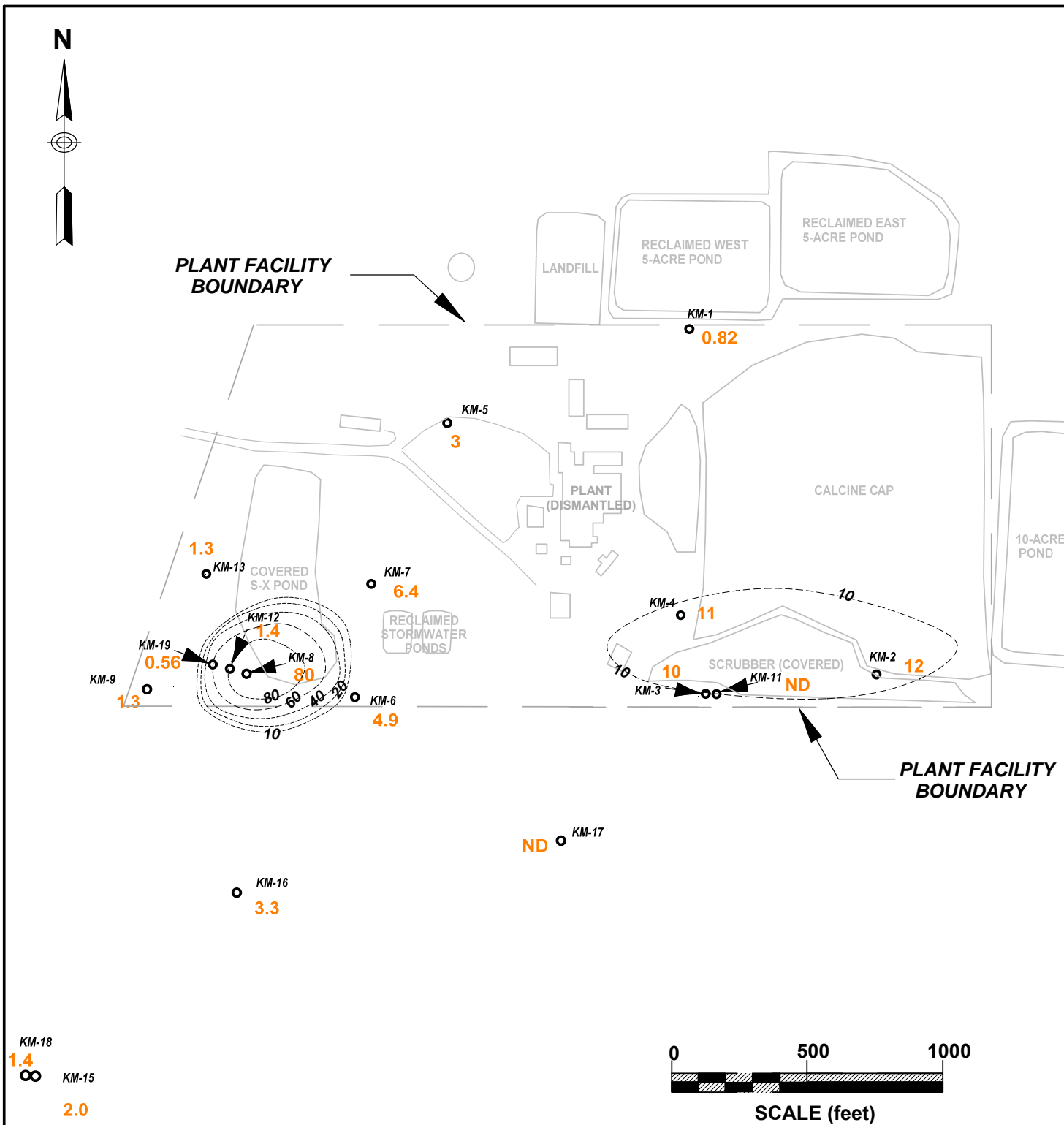
2009 ANNUAL COMPREHENSIVE  
GROUND WATER REPORT

CONCENTRATIONS OF  
SULFATE IN GROUND WATER  
MAY 2009

TRONOX  
SODA SPRINGS, IDAHO

FIGURE 4-5





NOTE: CONCENTRATIONS ARE IN ug/l.  
CONTOURS BASED ON CONCENTRATIONS  
IN SHALLOW AQUIFER.

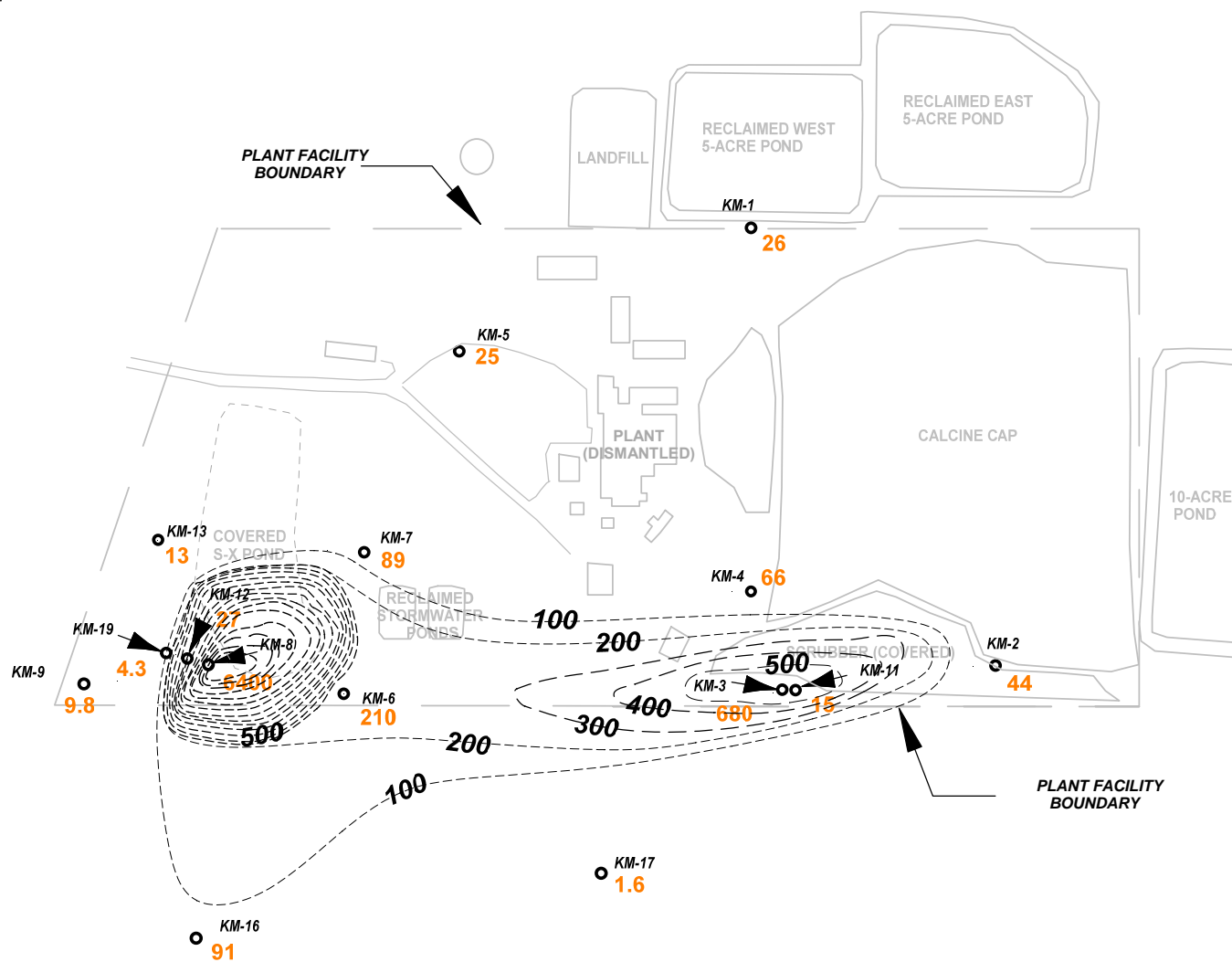
RBC FOR ARSENIC IS 10 ug/l

2009 ANNUAL COMPREHENSIVE  
GROUND WATER REPORT

## CONCENTRATIONS OF ARSENIC IN GROUND WATER MAY 2009

TRONOX  
SODA SPRINGS, IDAHO

FIGURE 4-6



KM-18  
40  
KM-15  
47



SCALE (feet)

NOTE: CONCENTRATIONS ARE IN ug/l.  
CONTOURS BASED ON CONCENTRATIONS  
IN SHALLOW AQUIFER.

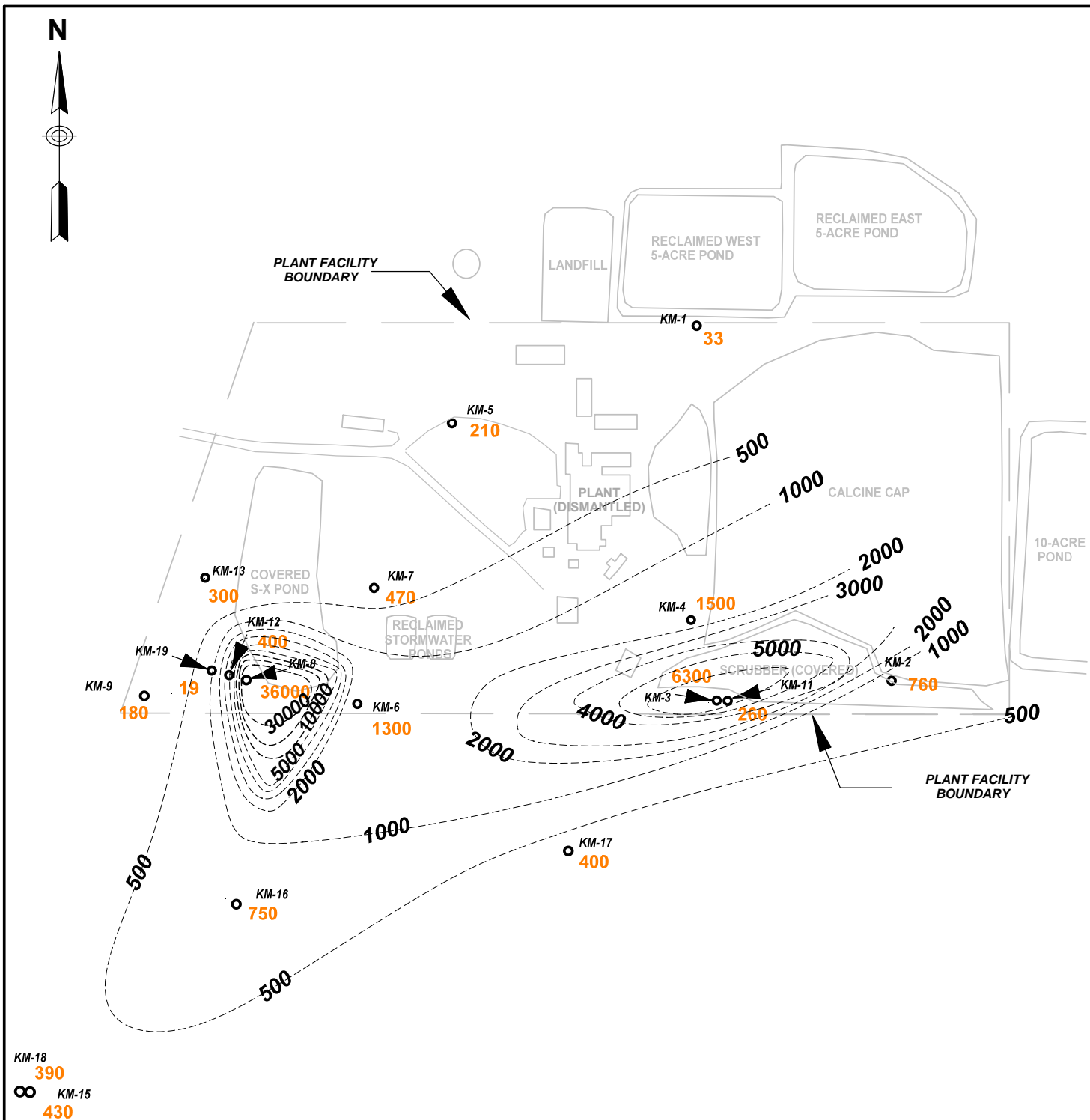
RBC FOR MANGANESE IS 180 ug/l

2009 ANNUAL COMPREHENSIVE  
GROUND WATER REPORT

## CONCENTRATIONS OF MANGANESE IN GROUND WATER MAY 2009

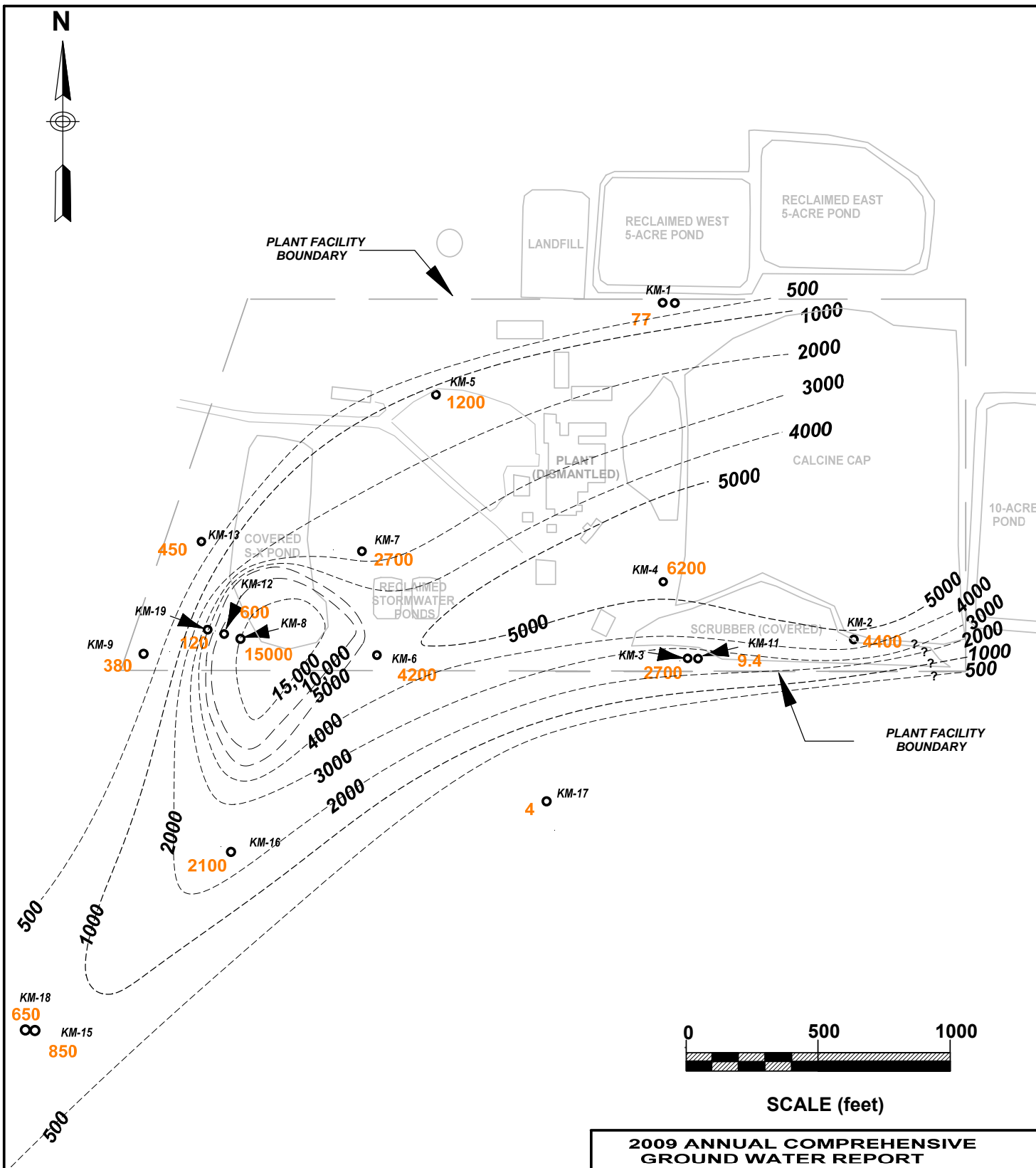
TRONOX  
SODA SPRINGS, IDAHO

FIGURE 4-7



NOTE: CONCENTRATIONS ARE IN ug/l.  
 CONTOURS BASED ON CONCENTRATIONS  
 IN SHALLOW AQUIFER.  
 RBC FOR MOLYBDENUM IS 180 ug/l.

2009 ANNUAL COMPREHENSIVE GROUND WATER REPORT	
<b>CONCENTRATIONS OF MOLYBDENUM IN GROUND WATER MAY 2009</b>	
TRONOX SODA SPRINGS, IDAHO	FIGURE 4-8



NOTE: CONCENTRATIONS ARE IN ug/l.  
CONCENTRATIONS BASED ON OBSERVED CONCENTRATIONS  
IN SHALLOW AQUIFER.

RBC FOR VANADIUM IS 260 ug/l .

# 2009 ANNUAL COMPREHENSIVE GROUND WATER REPORT

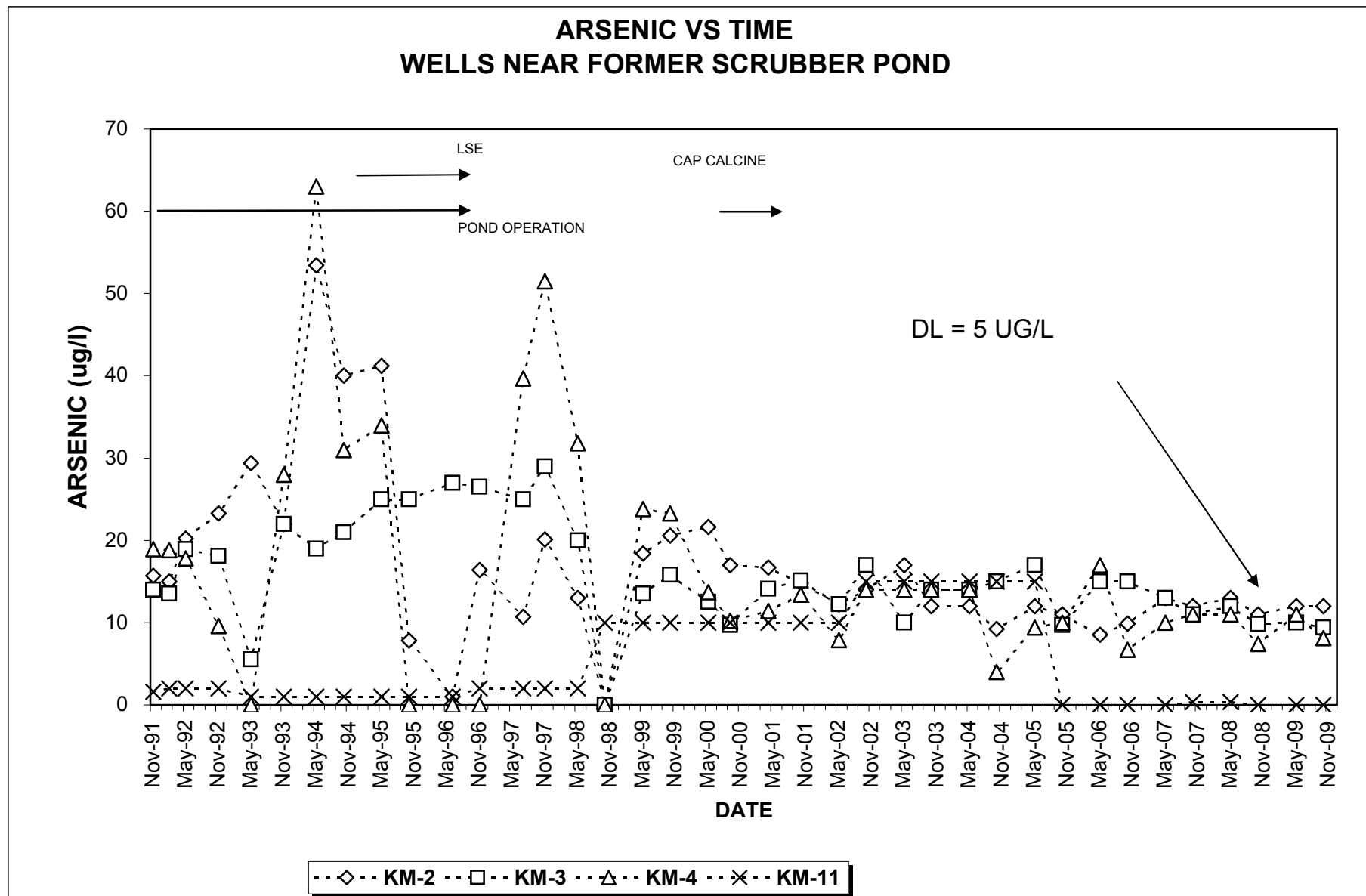
## CONCENTRATIONS OF VANADIUM IN GROUND WATER MAY 2009

TRONOX  
SODA SPRINGS, IDAHO

FIGURE 4-9

**APPENDIX A**

**GRAPHS OF GROUND AND SURFACE WATER  
QUALITY VERSUS TIME**

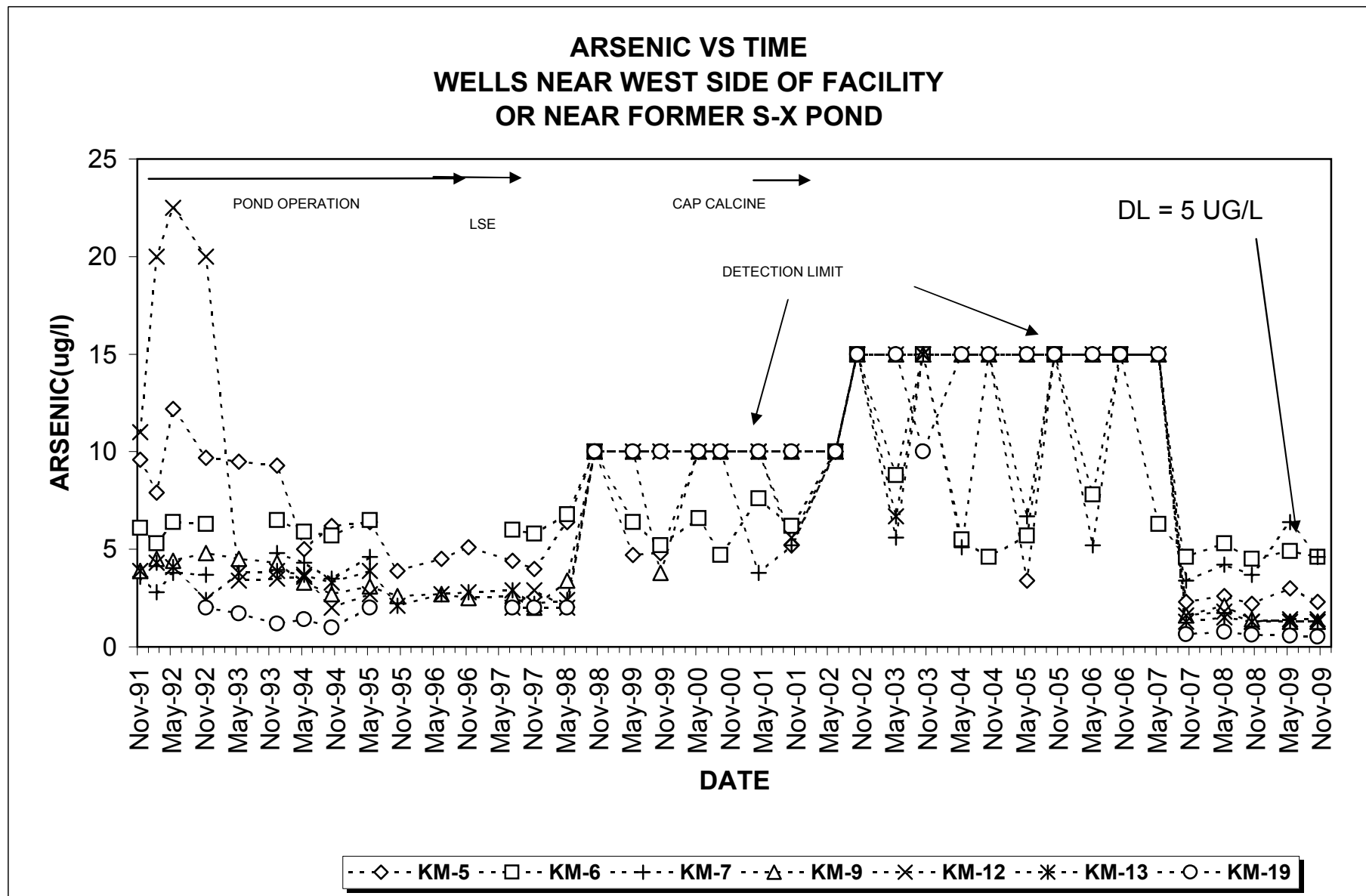


RBC FOR ARSENIC IS 10 ug/l

KM-2, KM-3, KM-11 ARE POC WELLS

VALUES LESS THAN DETECTION ARE PLOTTED AT DETECTION LIMIT

ARSENIC DETECTION LIMIT AT 10 to 15 UG/L 1999 THROUGH 2007

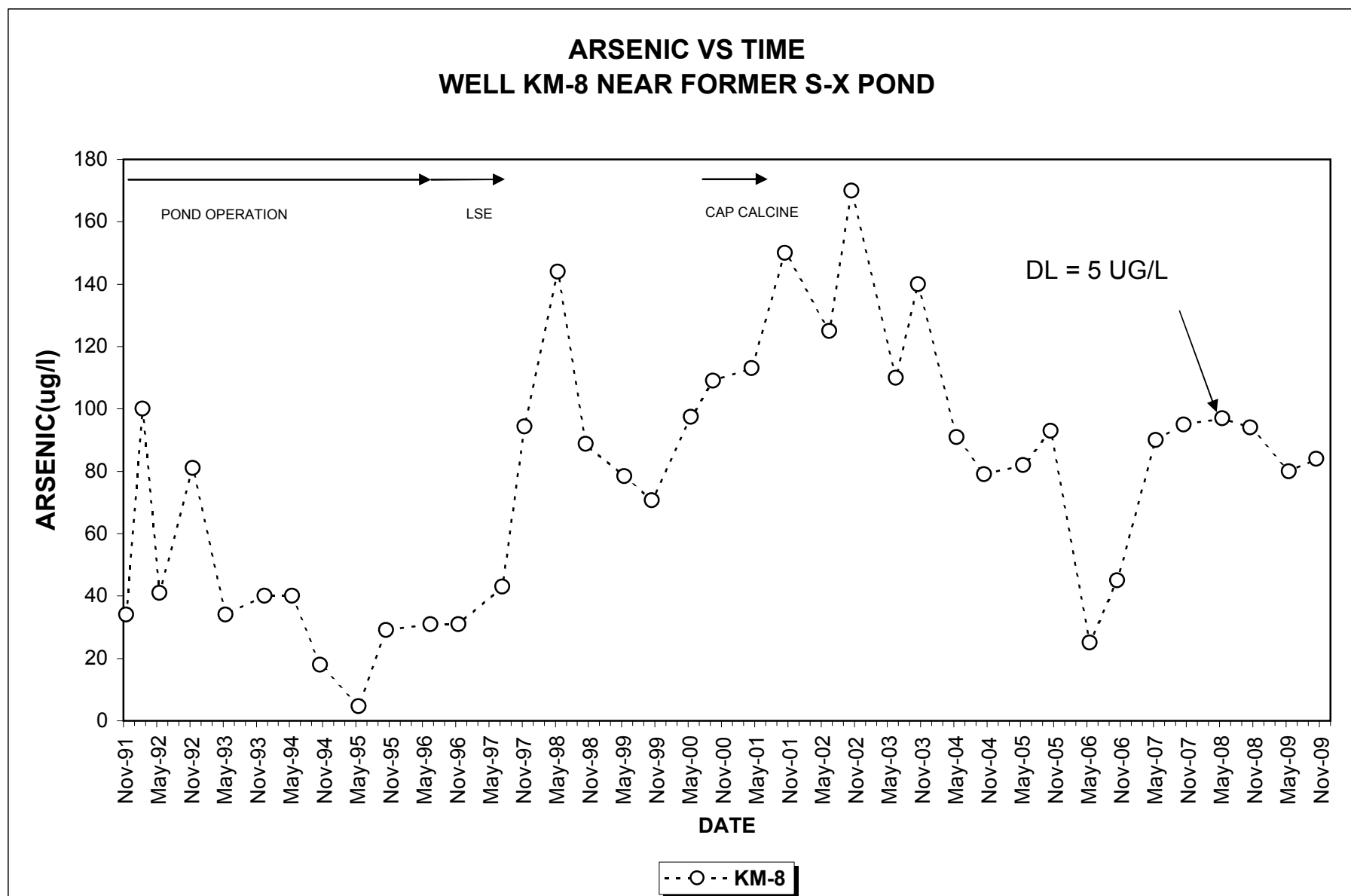


RBC FOR ARSENIC IS 10 ug/l

KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

VALUES LESS THAN DETECTION ARE PLOTTED AT THE DETECTION LIMIT

ARSENIC IS LESS THAN DETECTION OR REPORTING LIMIT IN ALL WELLS DURING 2003 through May 2007

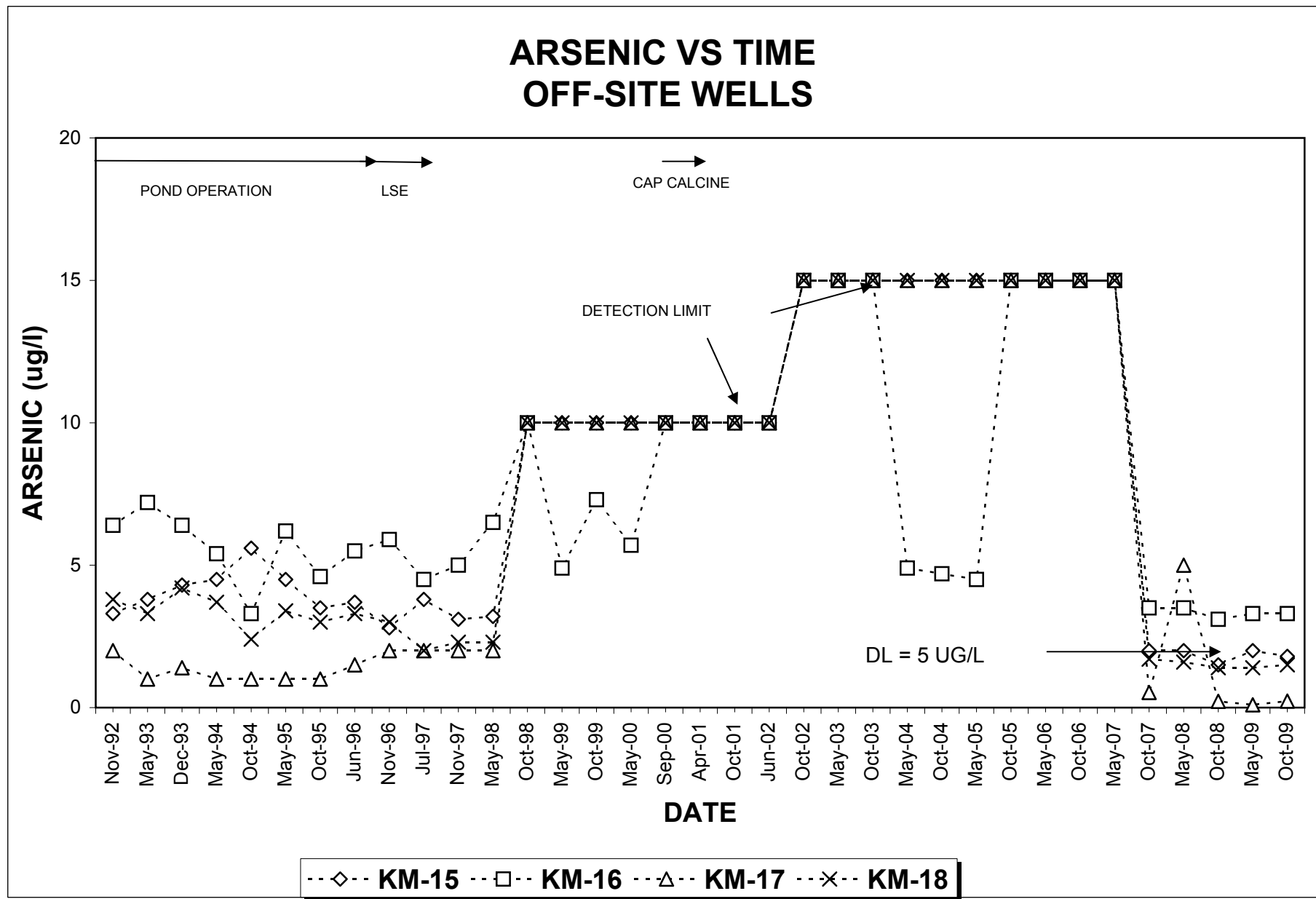


RBC FOR ARSENIC IS 10 ug/l

KM-8 IS A POC WELL

VALUES LESS THAN DETECTION ARE PLOTTED AT THE DETECTION LIMIT

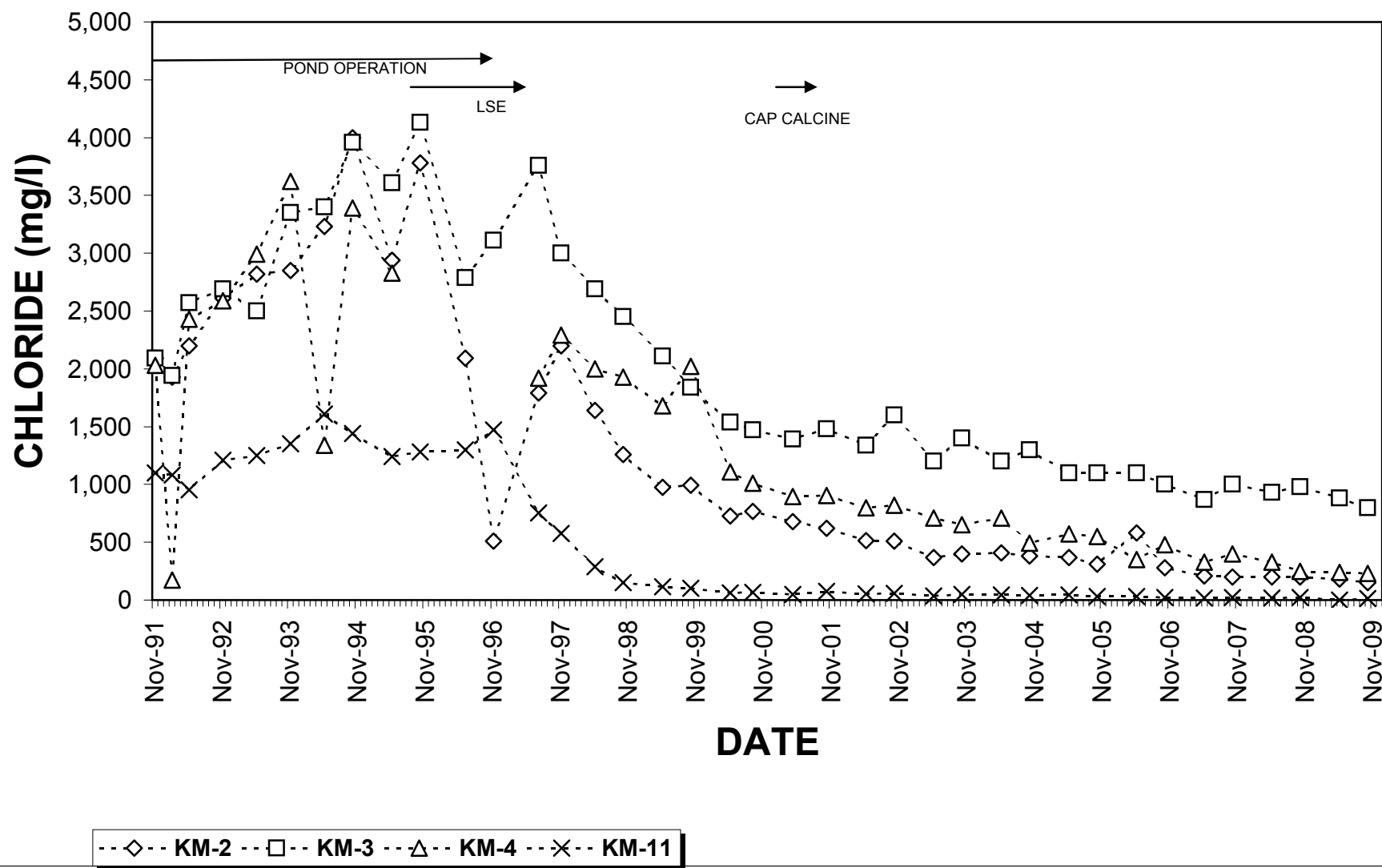




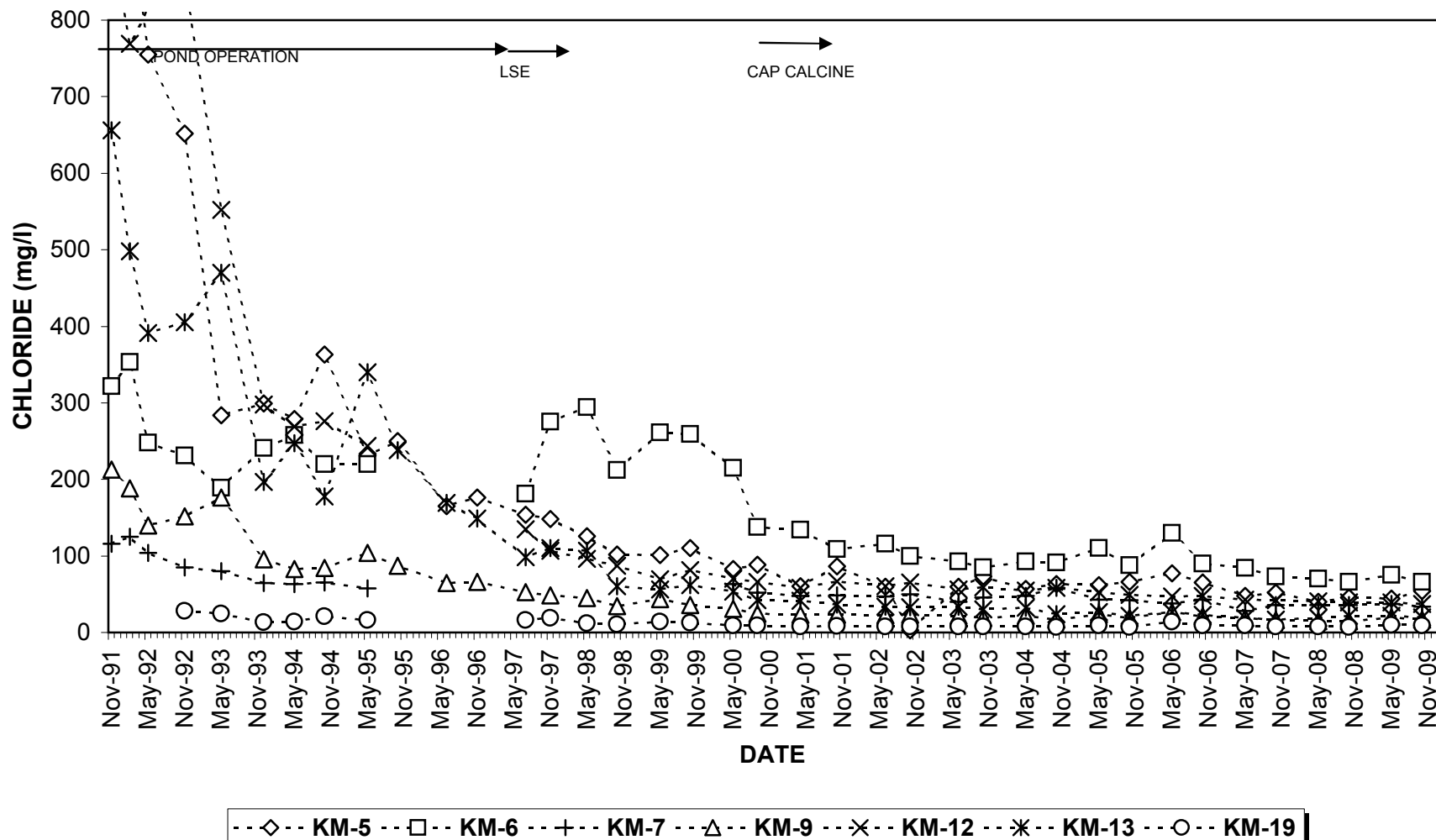
RBC = 10 ug/l

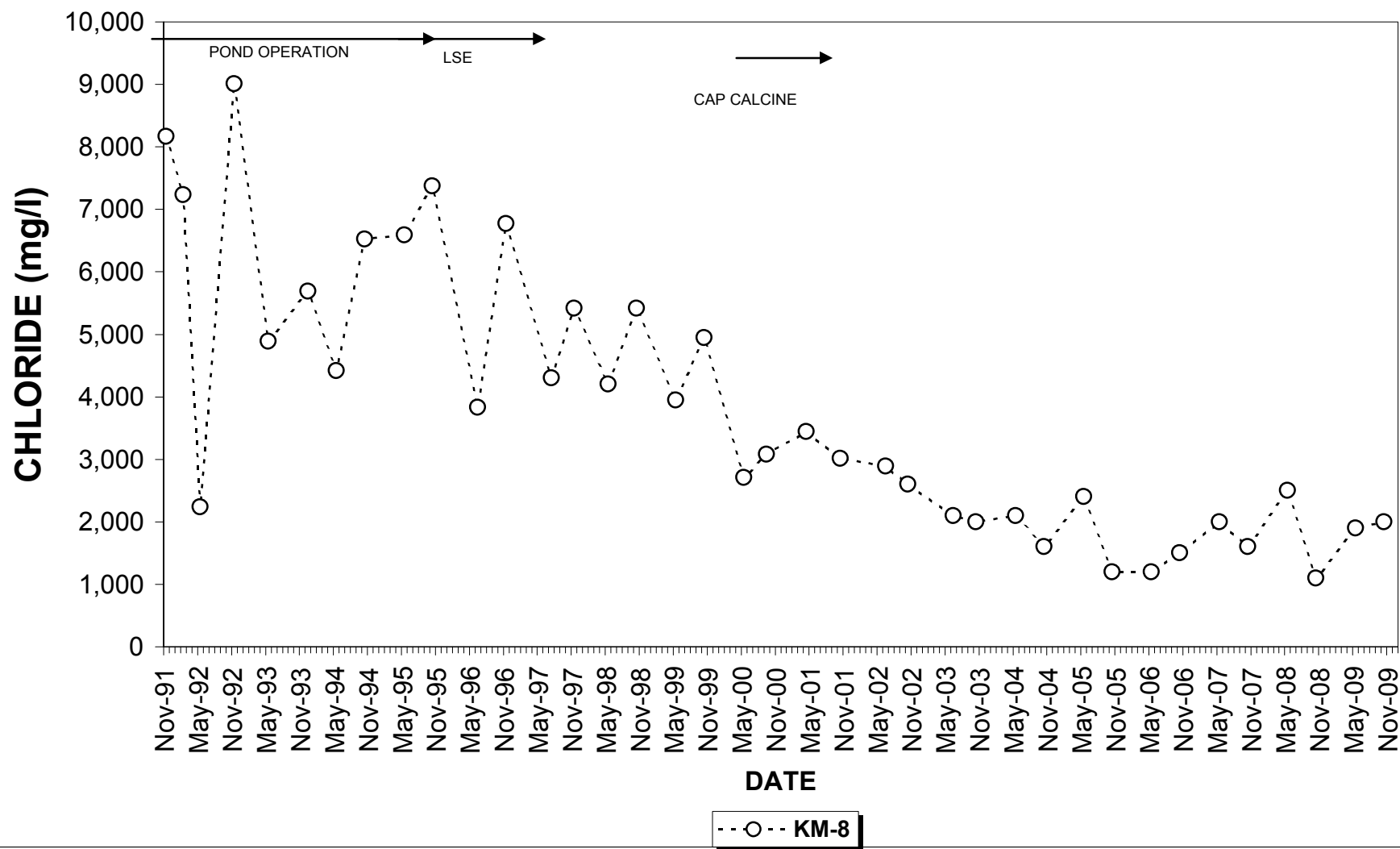
Values less than detection plotted at the detection limit

## CHLORIDE VS TIME WELLS NEAR FORMER SCRUBBER POND

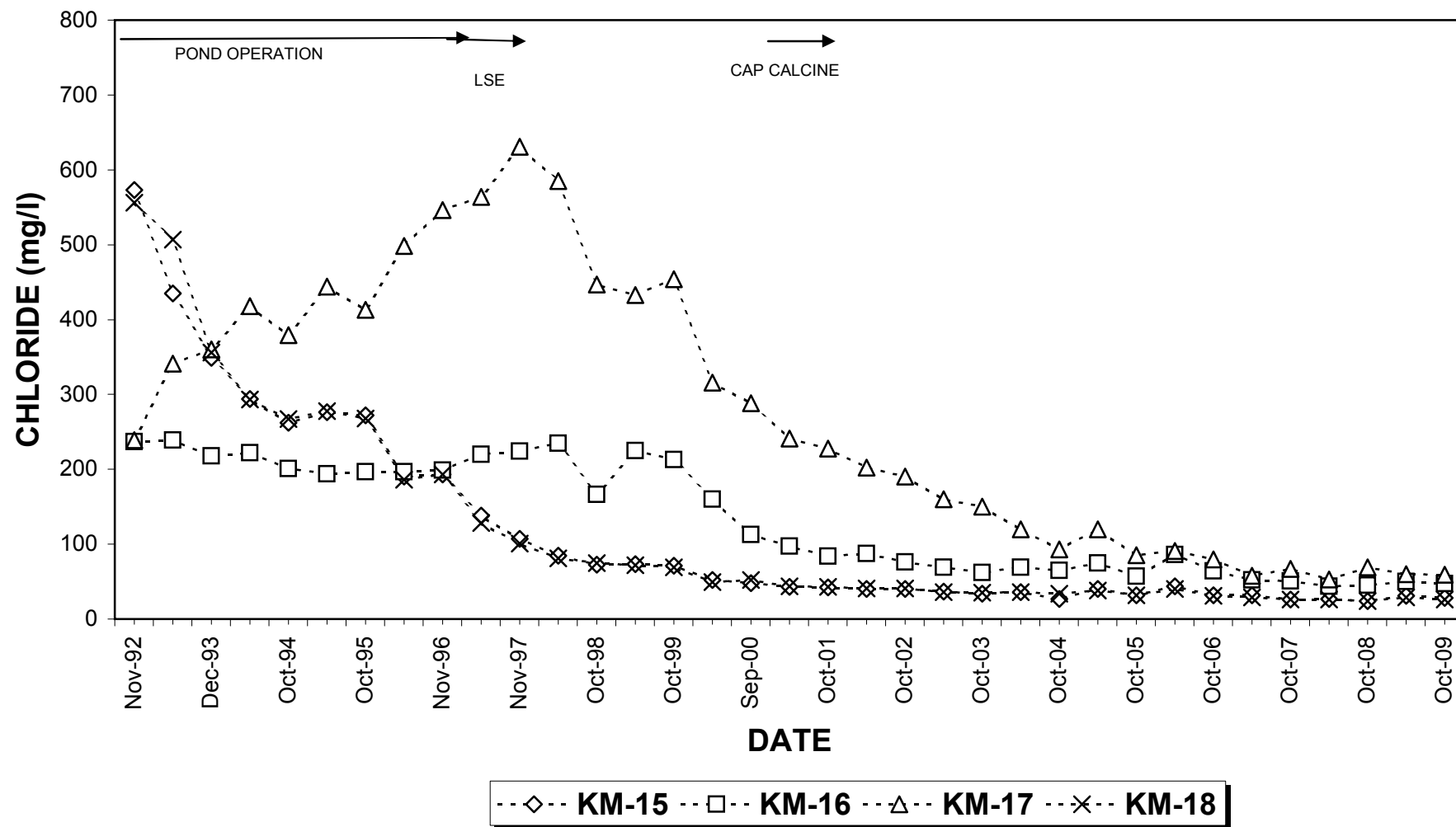


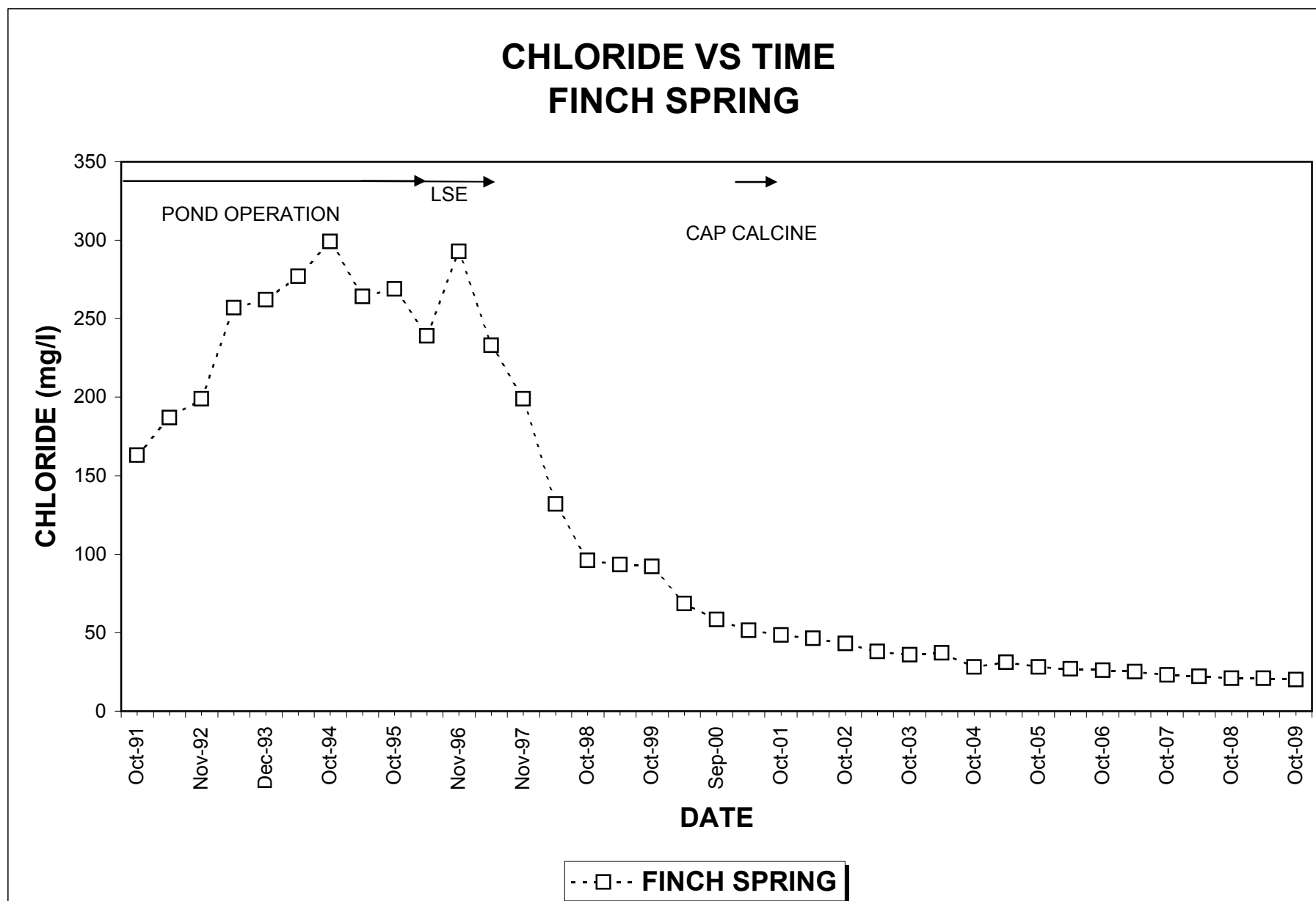
### CHLORIDE VS TIME WELLS NEAR WEST SIDE OF FACILITY OR NEAR FORMER S-X POND



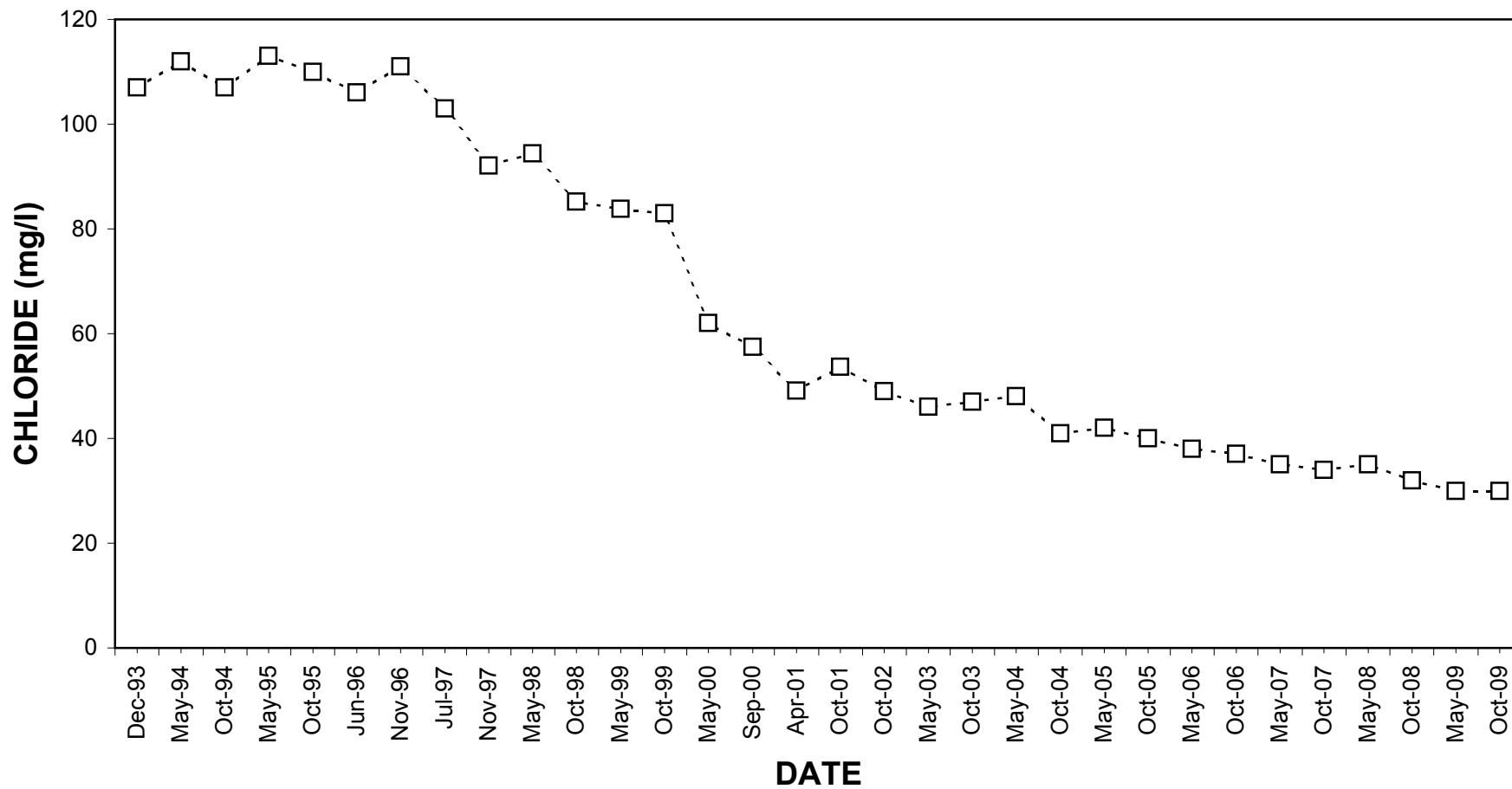
**CHLORIDE VS TIME  
WELL KM-8 NEAR FORMER S-X POND**

## CHLORIDE VS TIME OFF-SITE WELLS



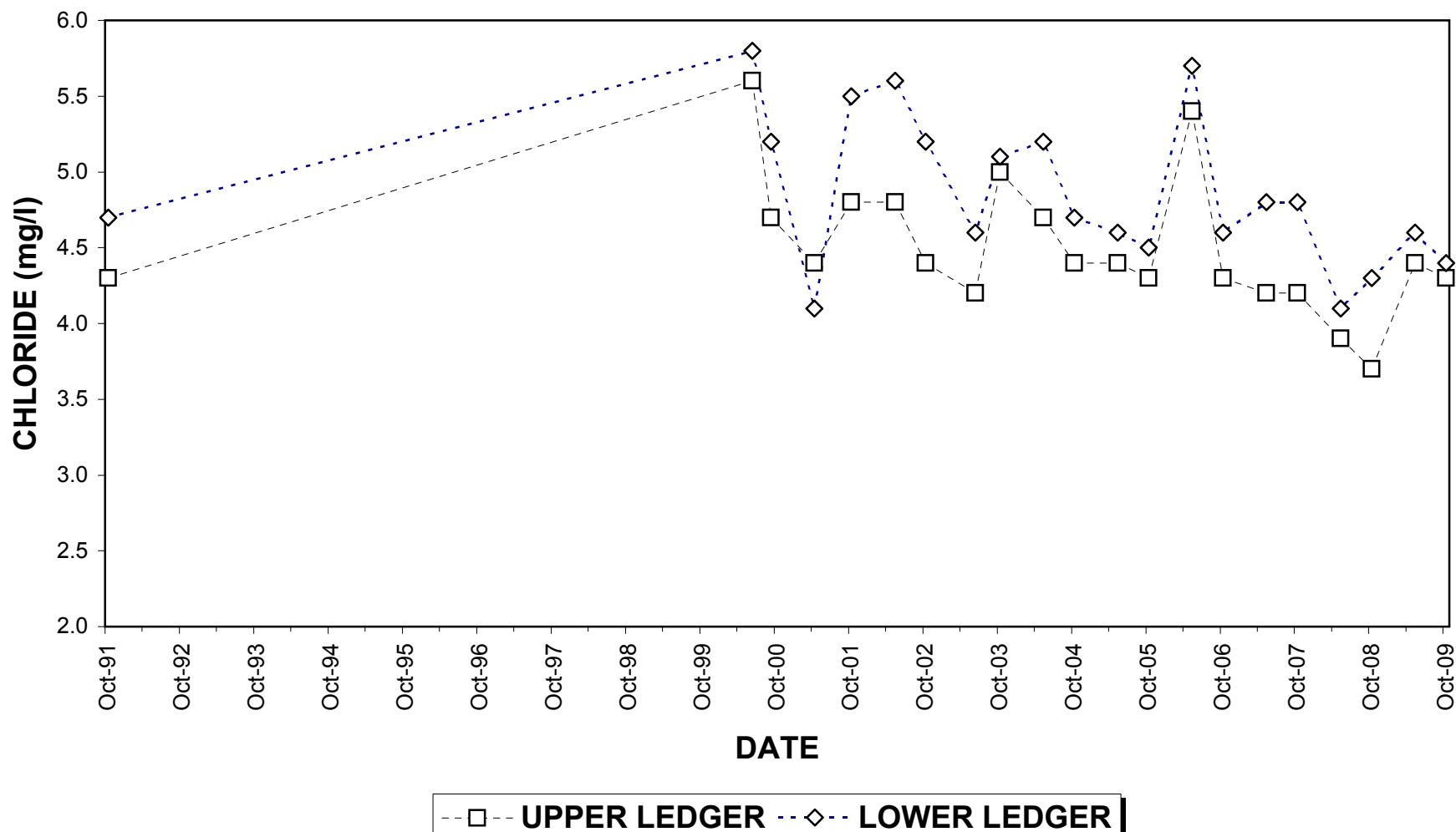


## CHLORIDE VS TIME BIG SPRING

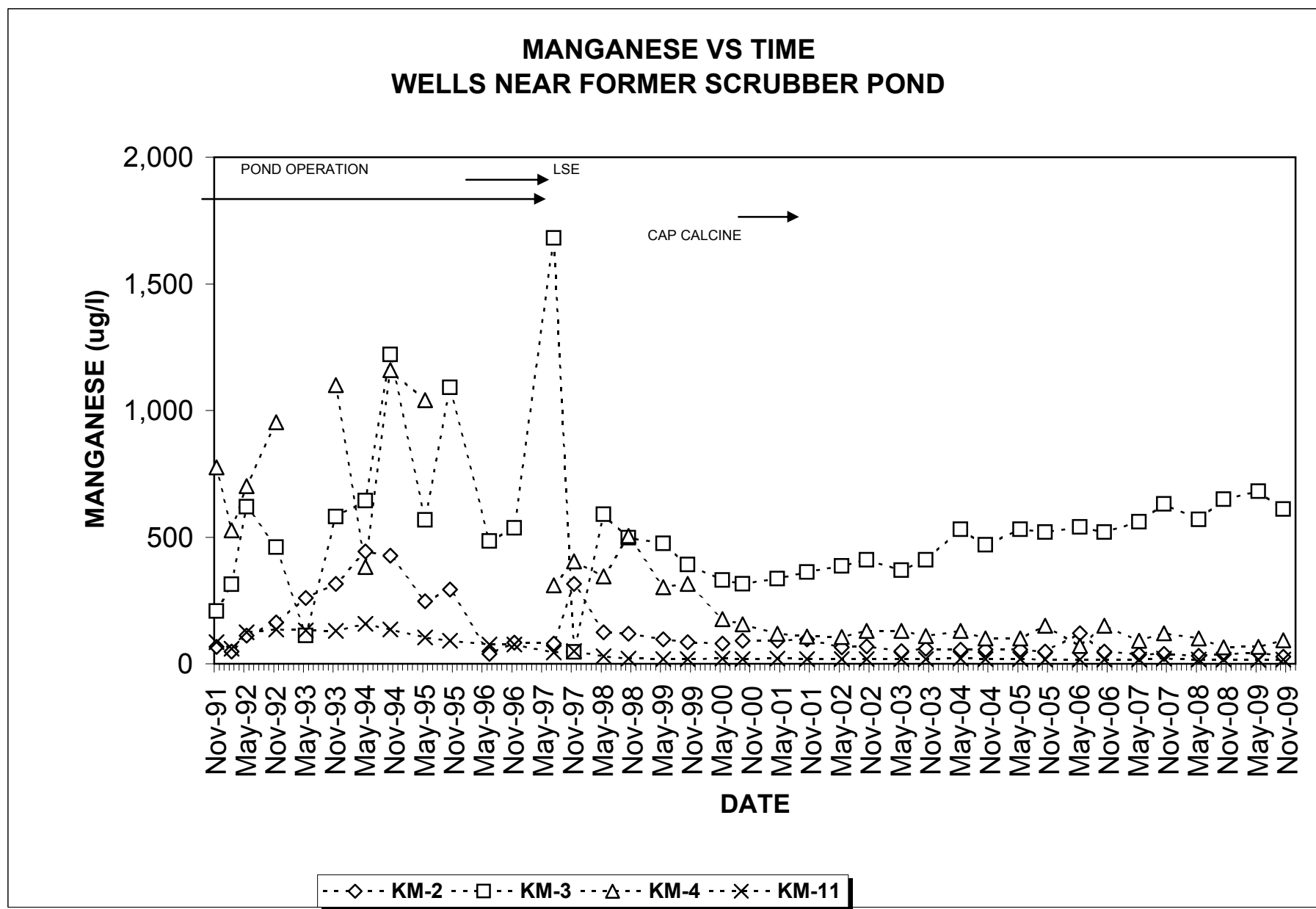


--□-- BIG SPRING

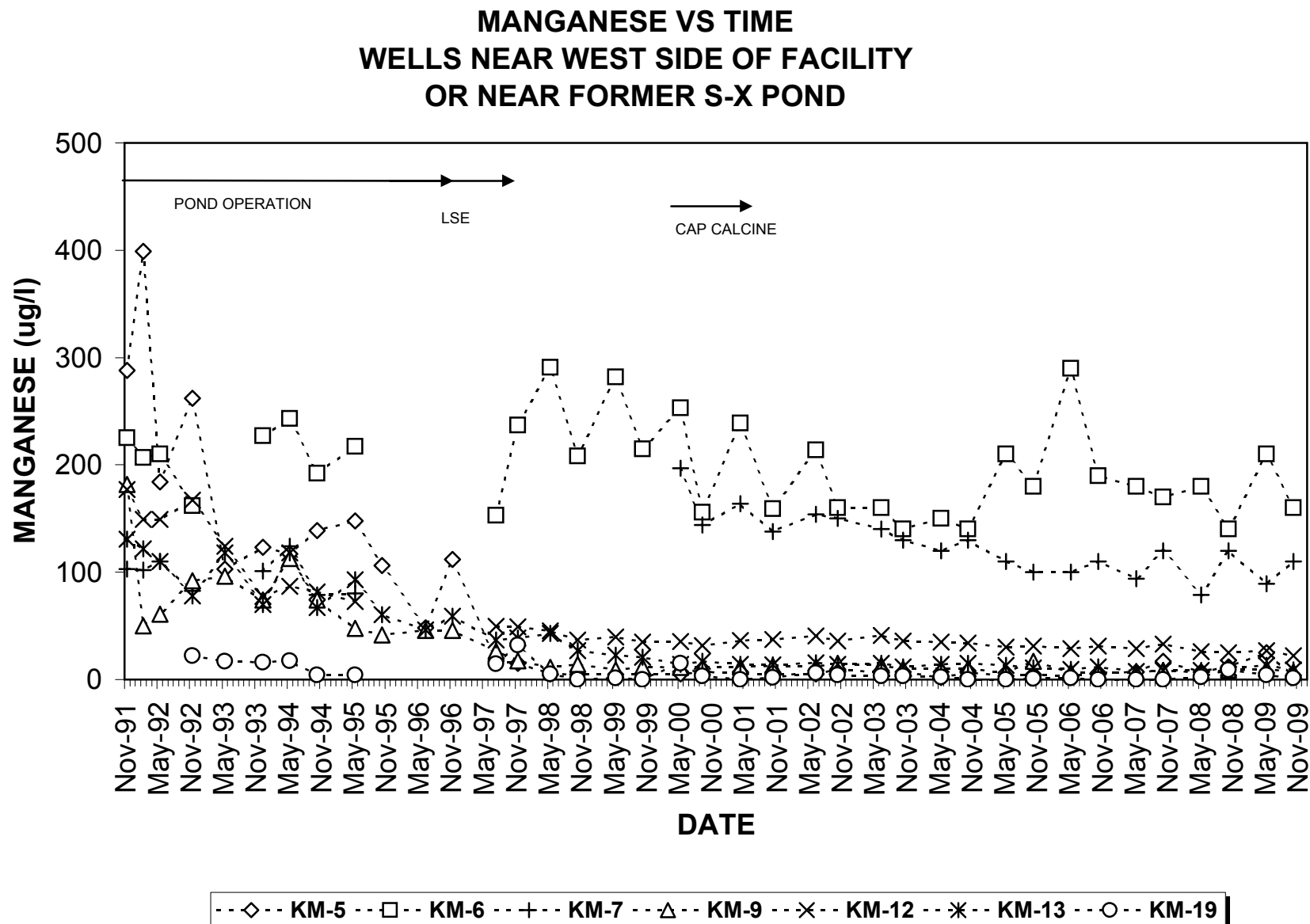
## CHLORIDE VS TIME UPPER AND LOWER LEDGER SPRINGS





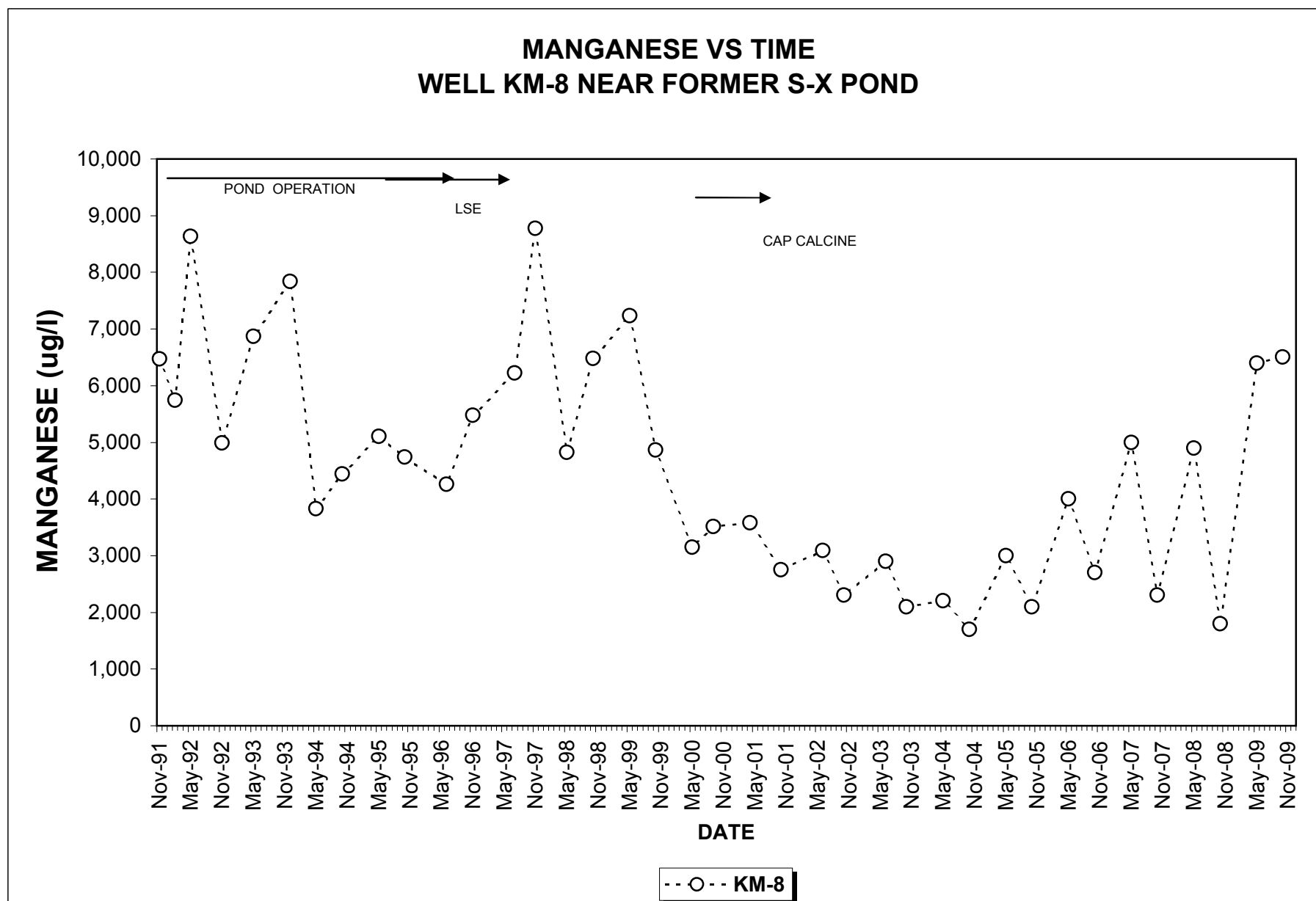


RBC FOR MANGANESE IS 180 ug/l  
KM-2, KM-3, KM-11 ARE POC WELLS



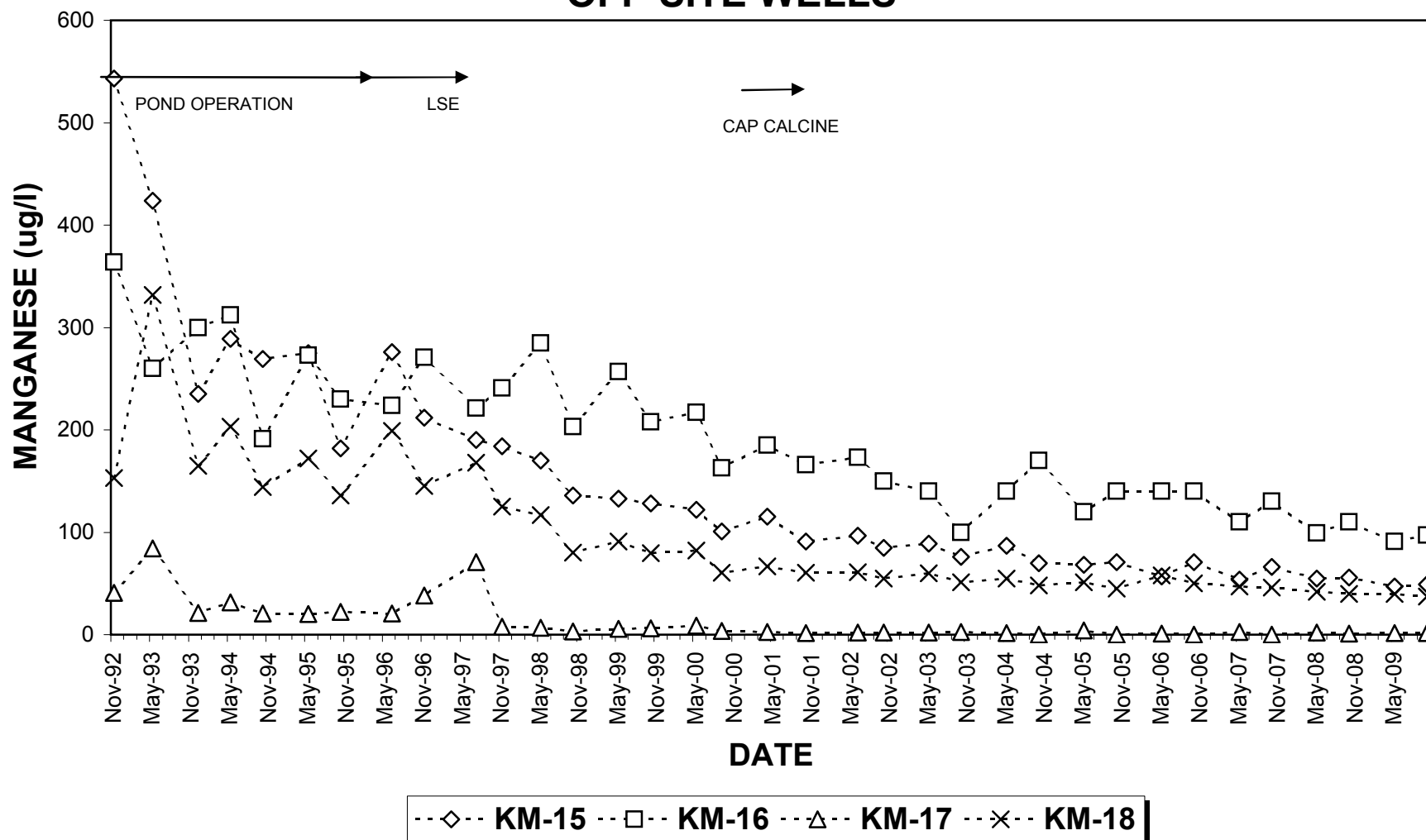
RBC FOR MANGANESE IS 180 ug/l

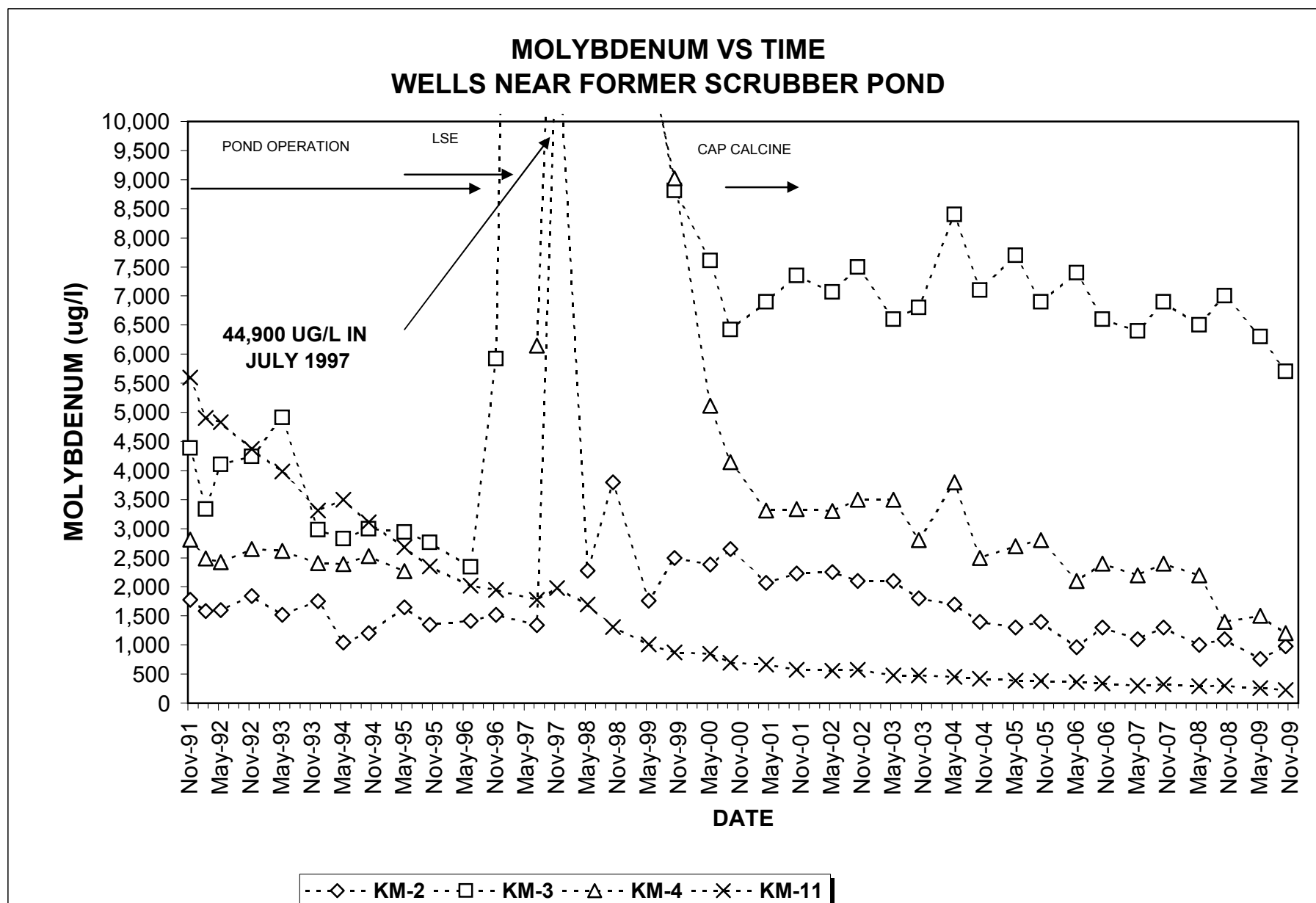
KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS



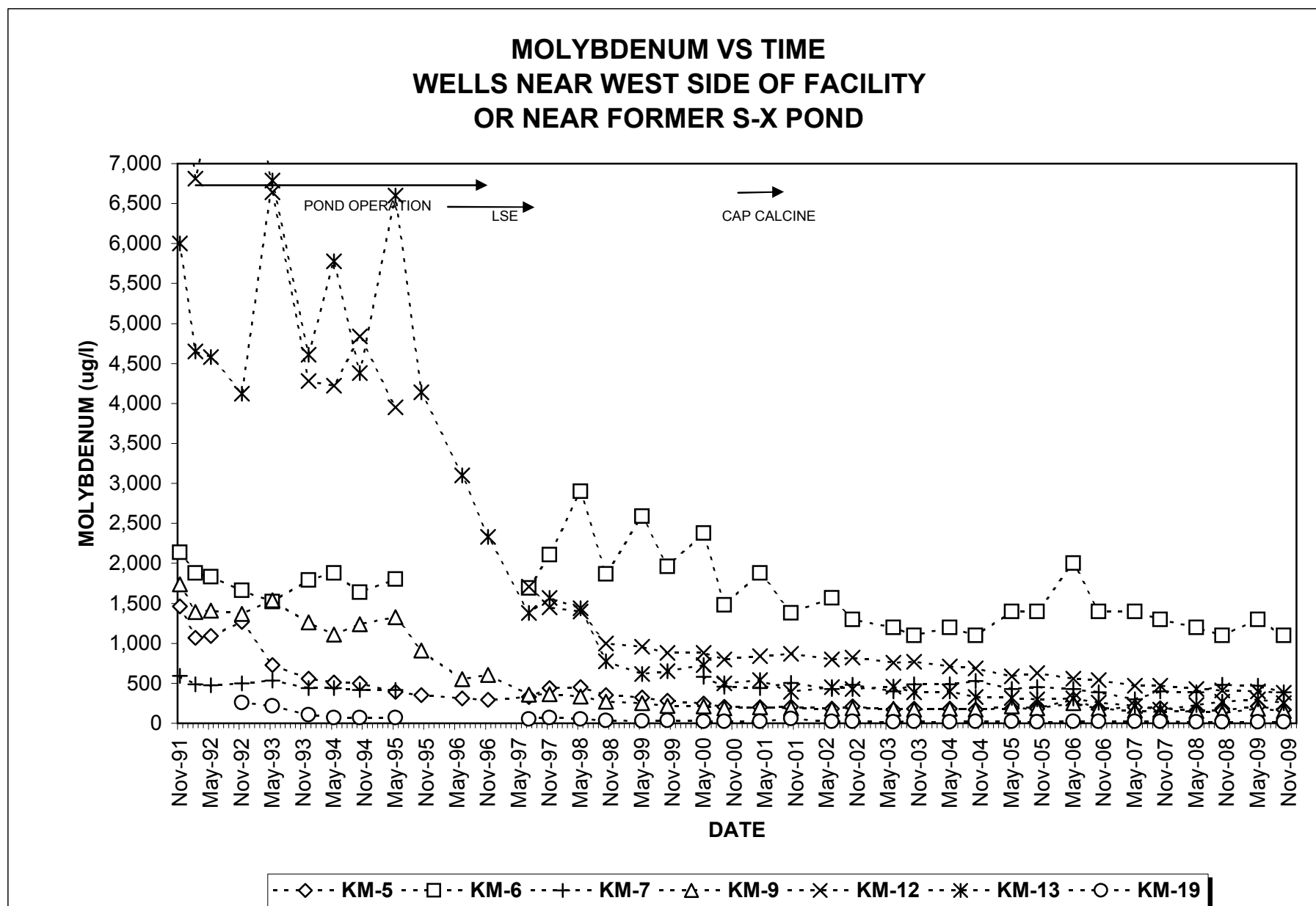
RBC FOR MANGANESE IS 180 ug/l  
KM-8 IS A POC WELL

## MANGANESE VS TIME OFF-SITE WELLS



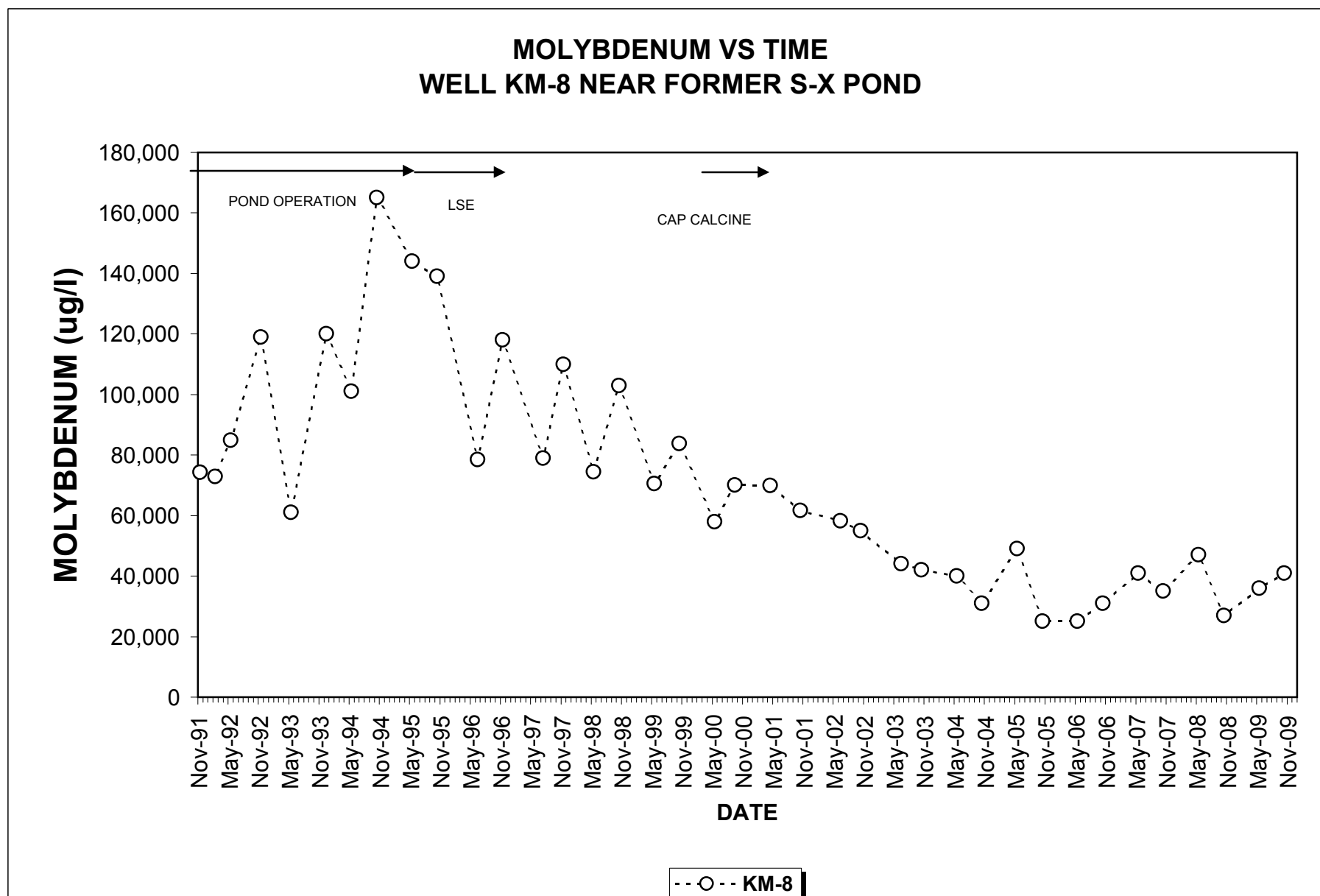


RBC FOR MOLYBDENUM IS 180 ug/l  
KM-2, KM-3, KM-11 ARE POC WELLS



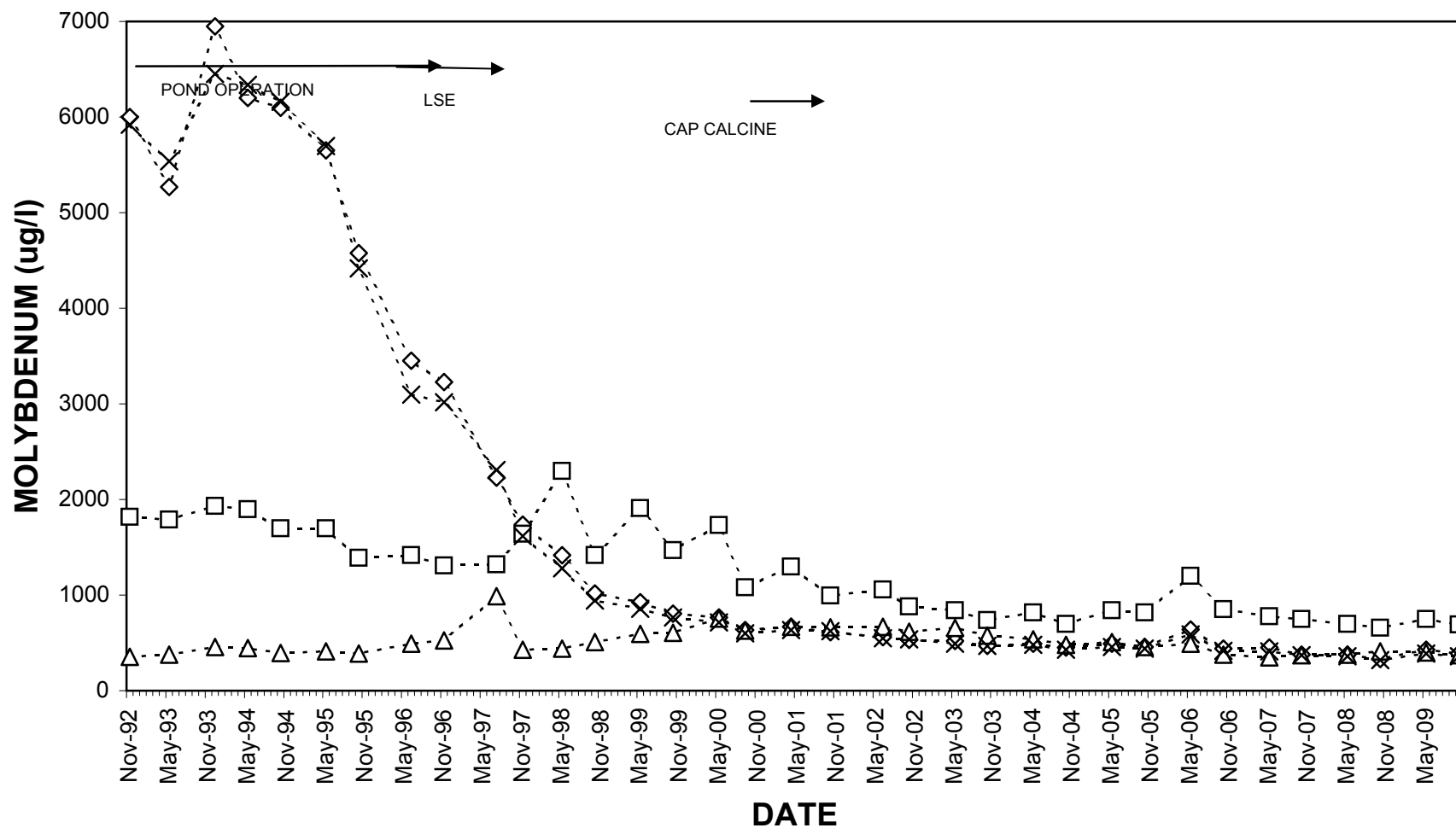
RBC FOR MOLYBDENUM IS 180 ug/l

KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS



RBC FOR MOLYBDENUM IS 180 ug/l  
KM-8 IS A POC WELL

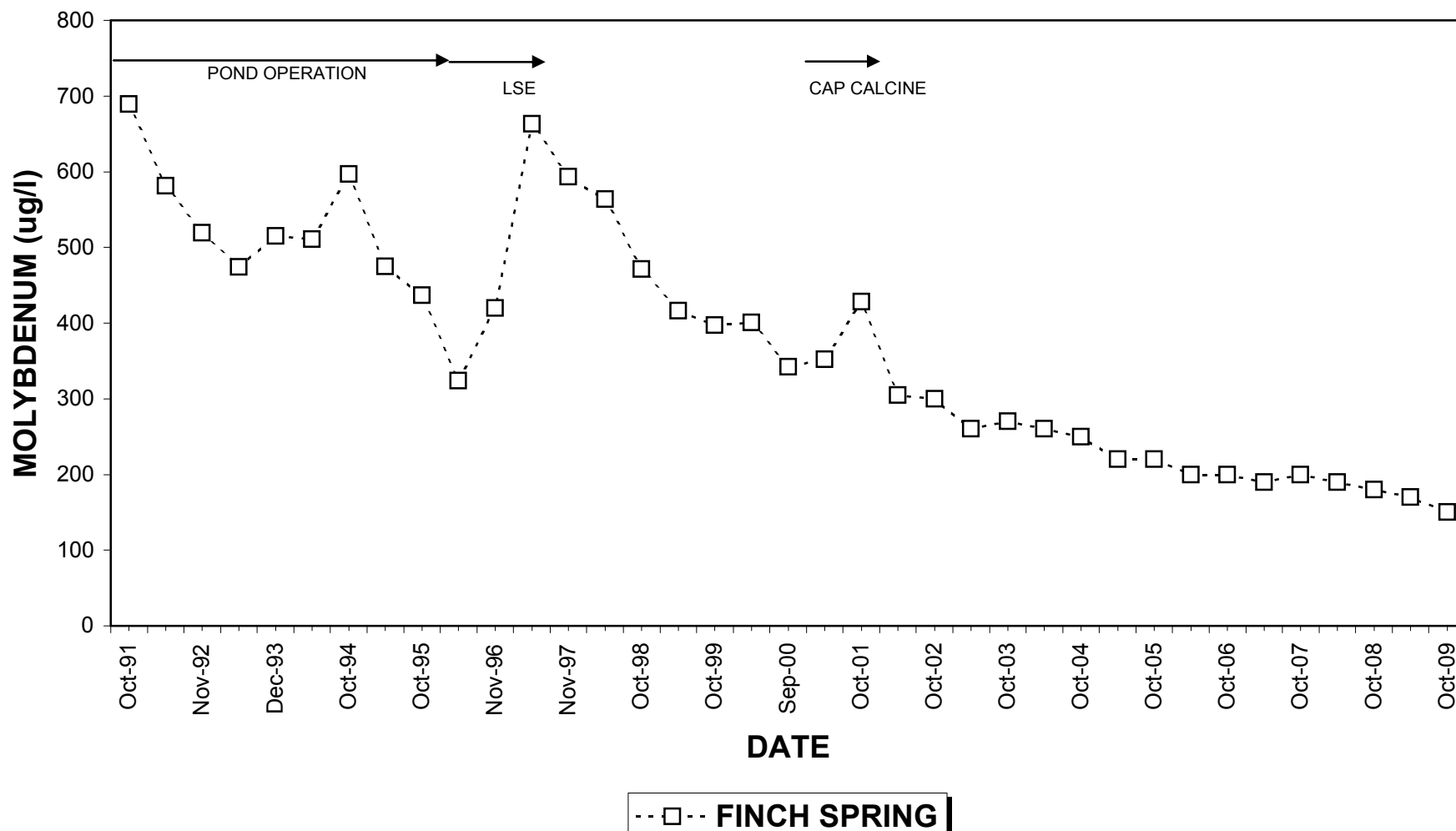
## MOLYBDENUM VS TIME OFF-SITE WELLS



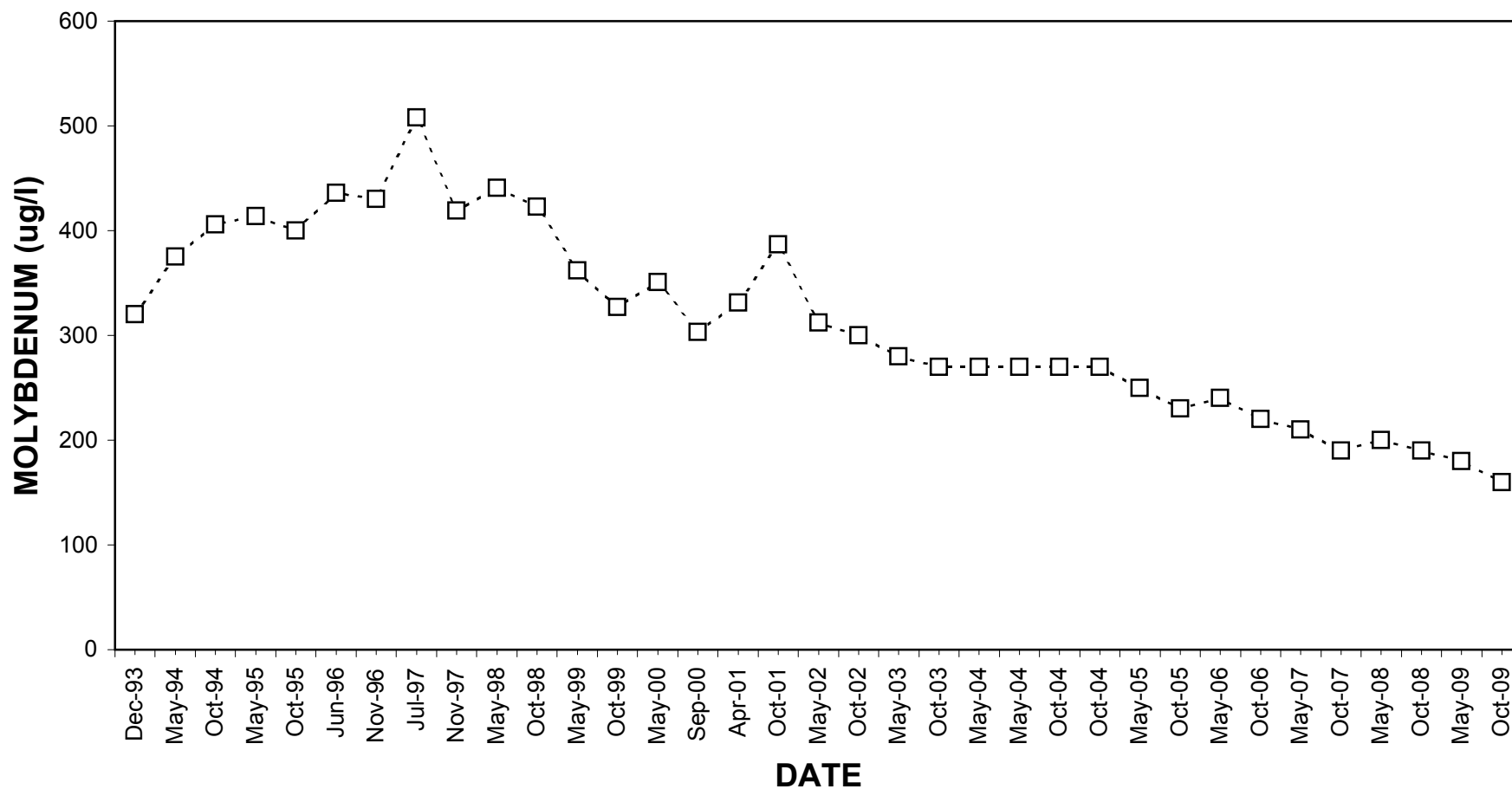
---◇--- KM-15 ---□--- KM-16 ---△--- KM-17 ---×--- KM-18



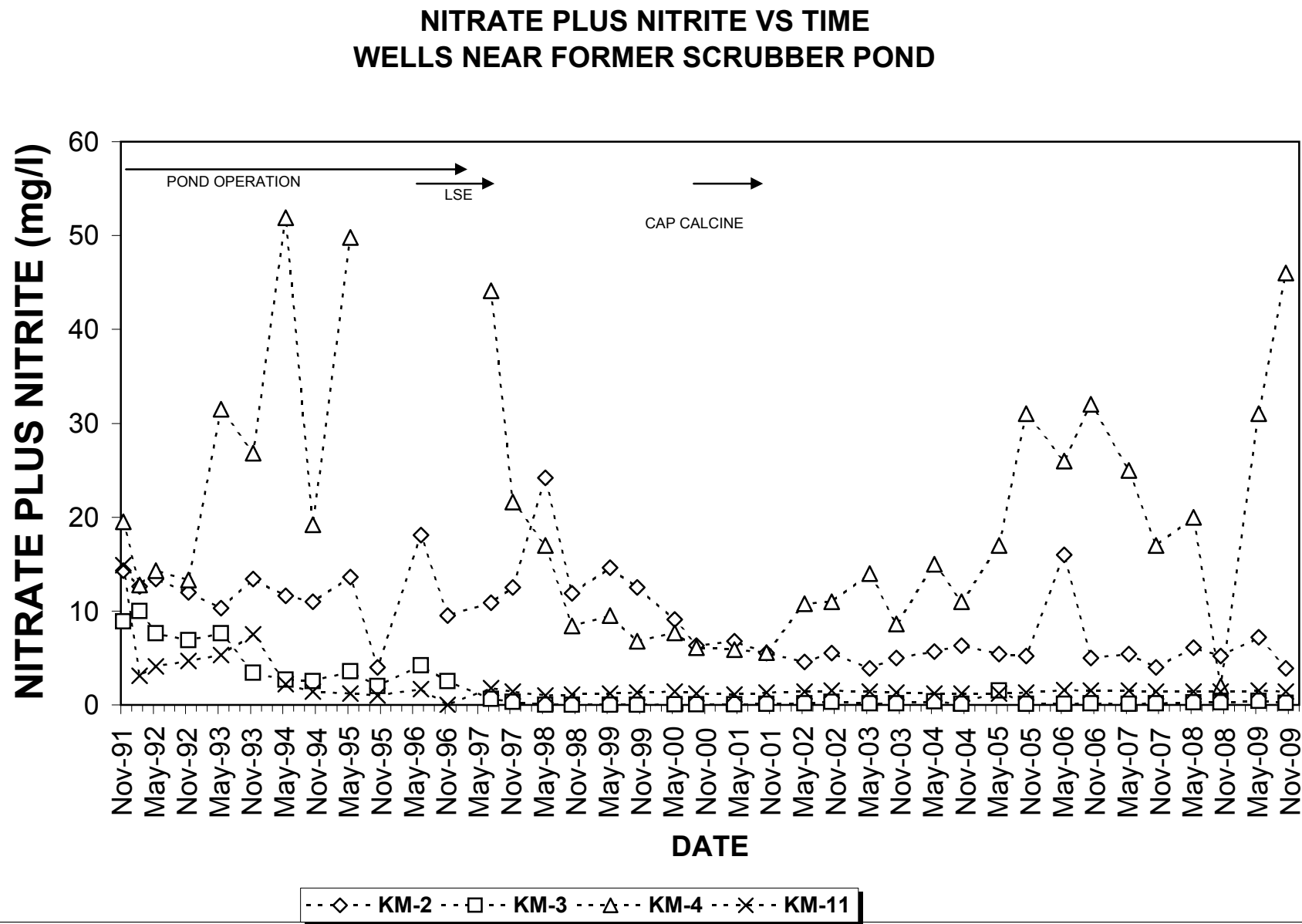
## MOLYBDENUM VS TIME FINCH SPRING



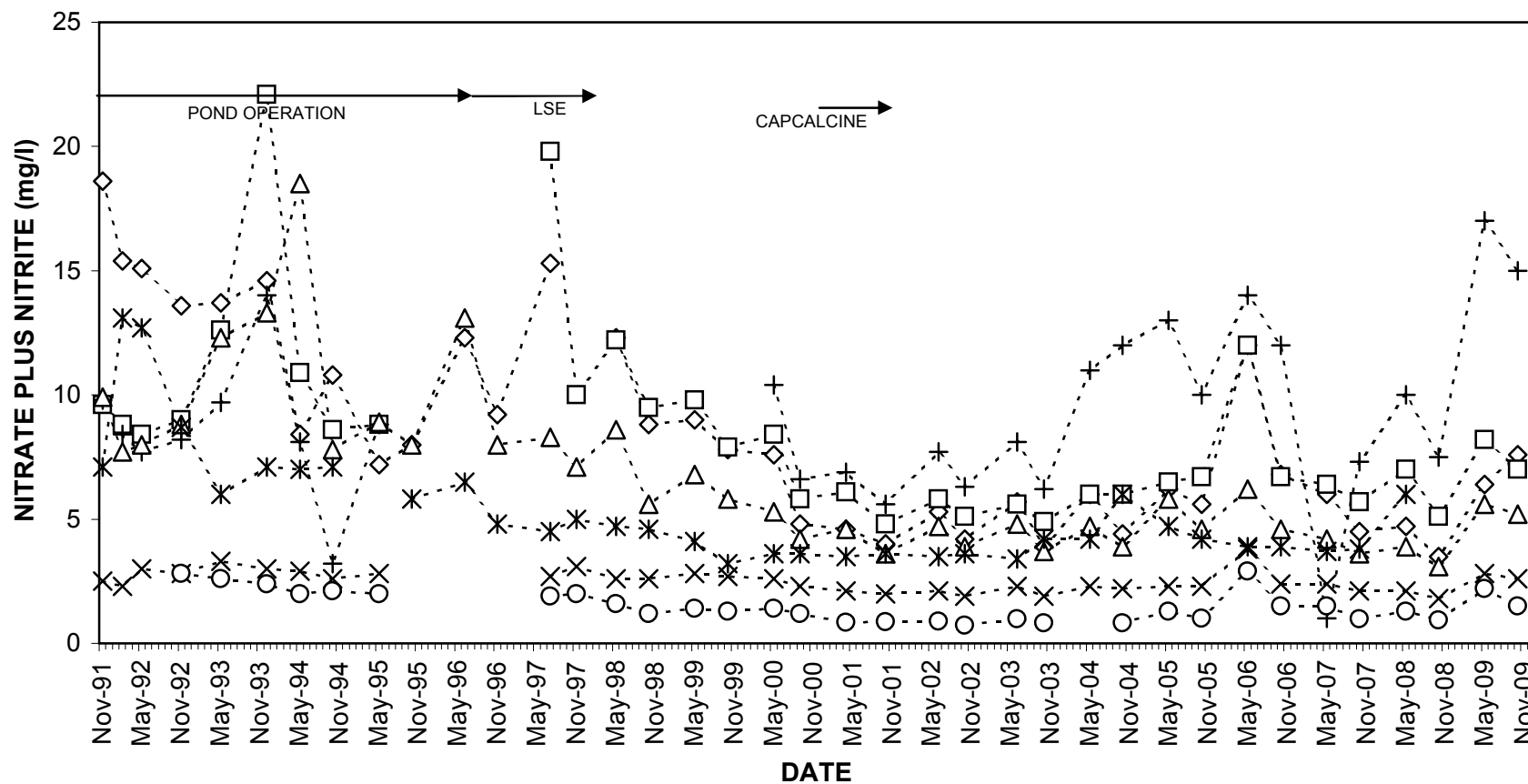
## MOLYBDENUM VS TIME BIG SPRING



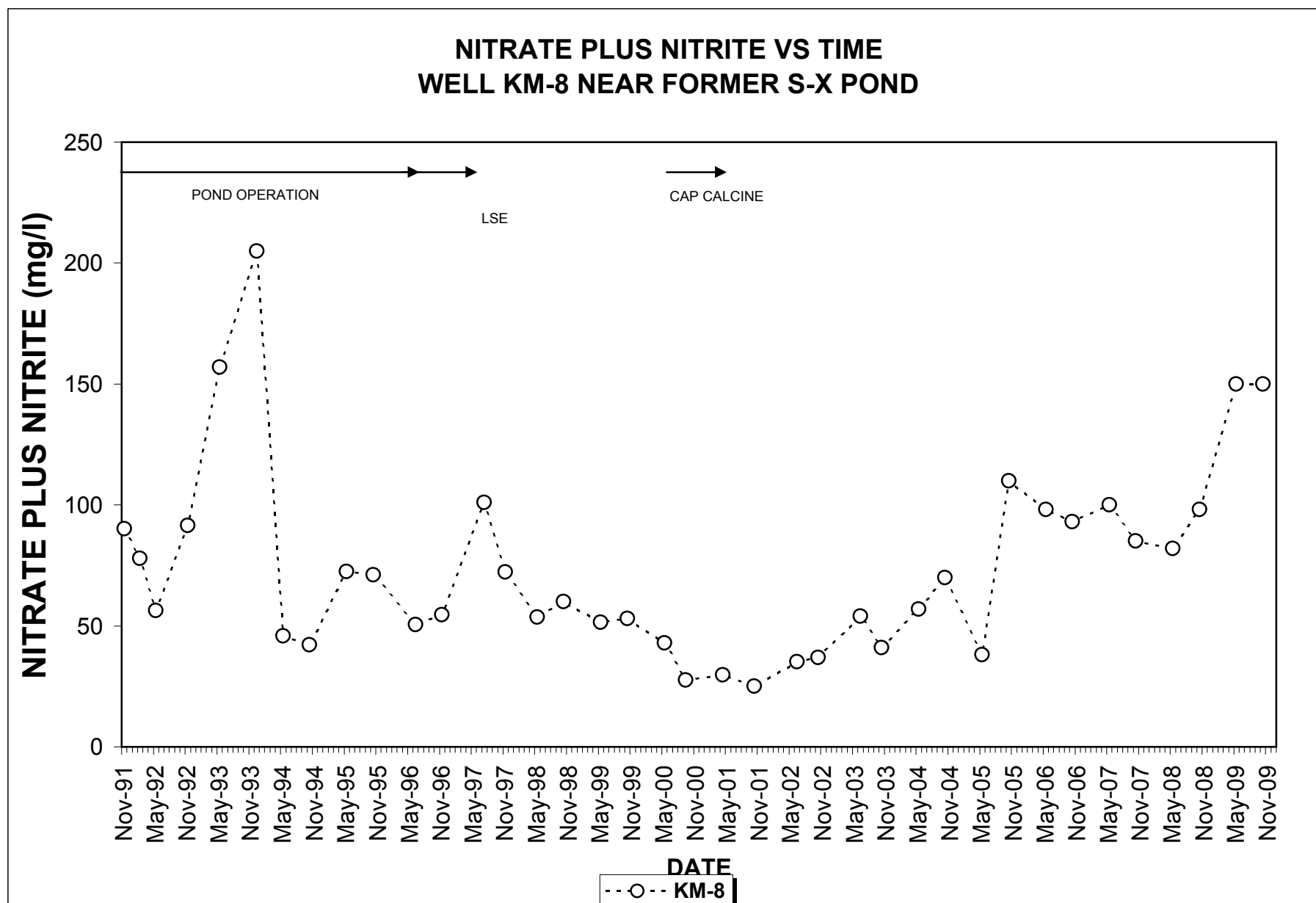
---□--- BIG SPRING



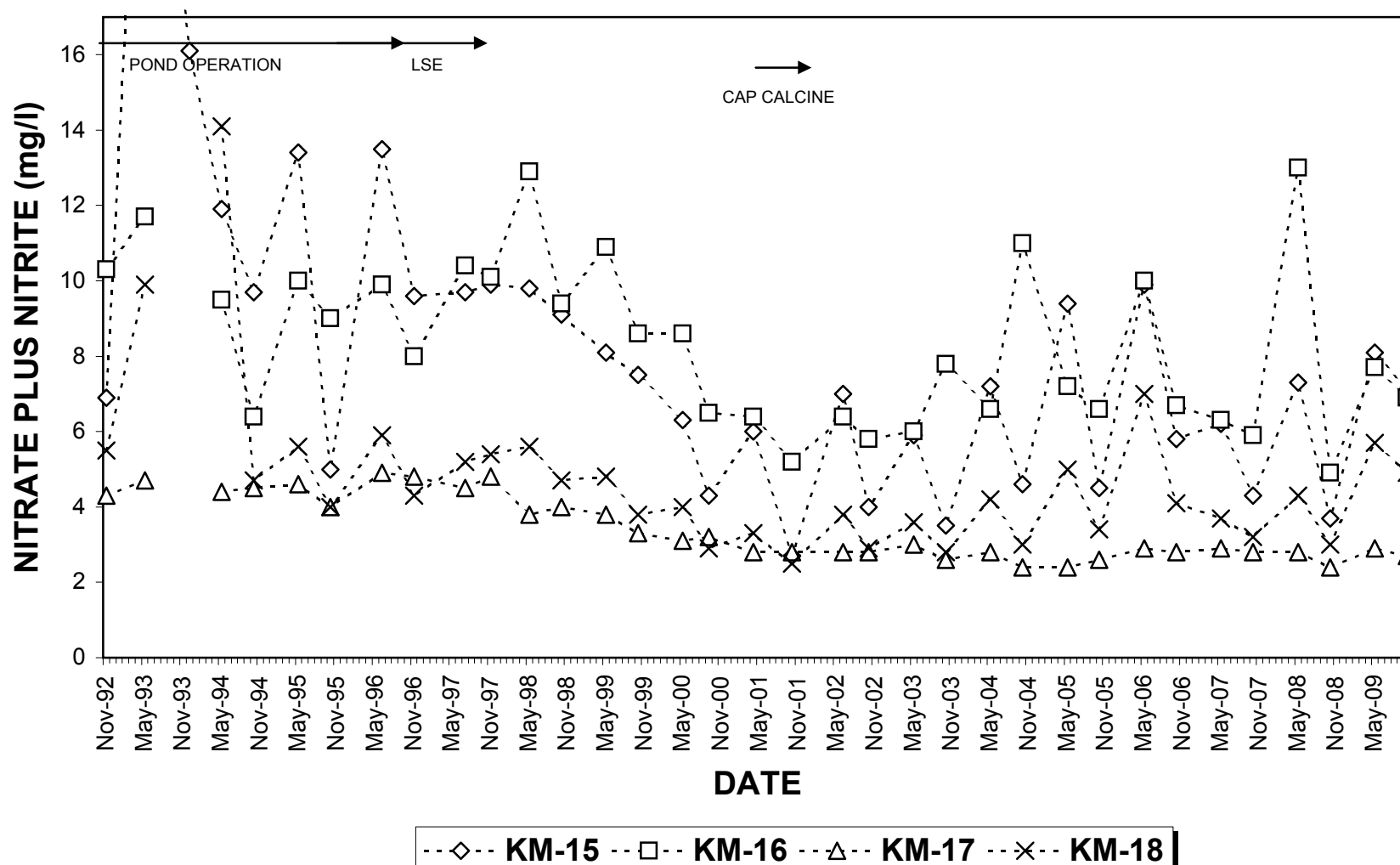
### NITRATE PLUS NITRITE VS TIME WELLS NEAR WEST SIDE OF FACILITY OR NEAR FORMER S-X POND



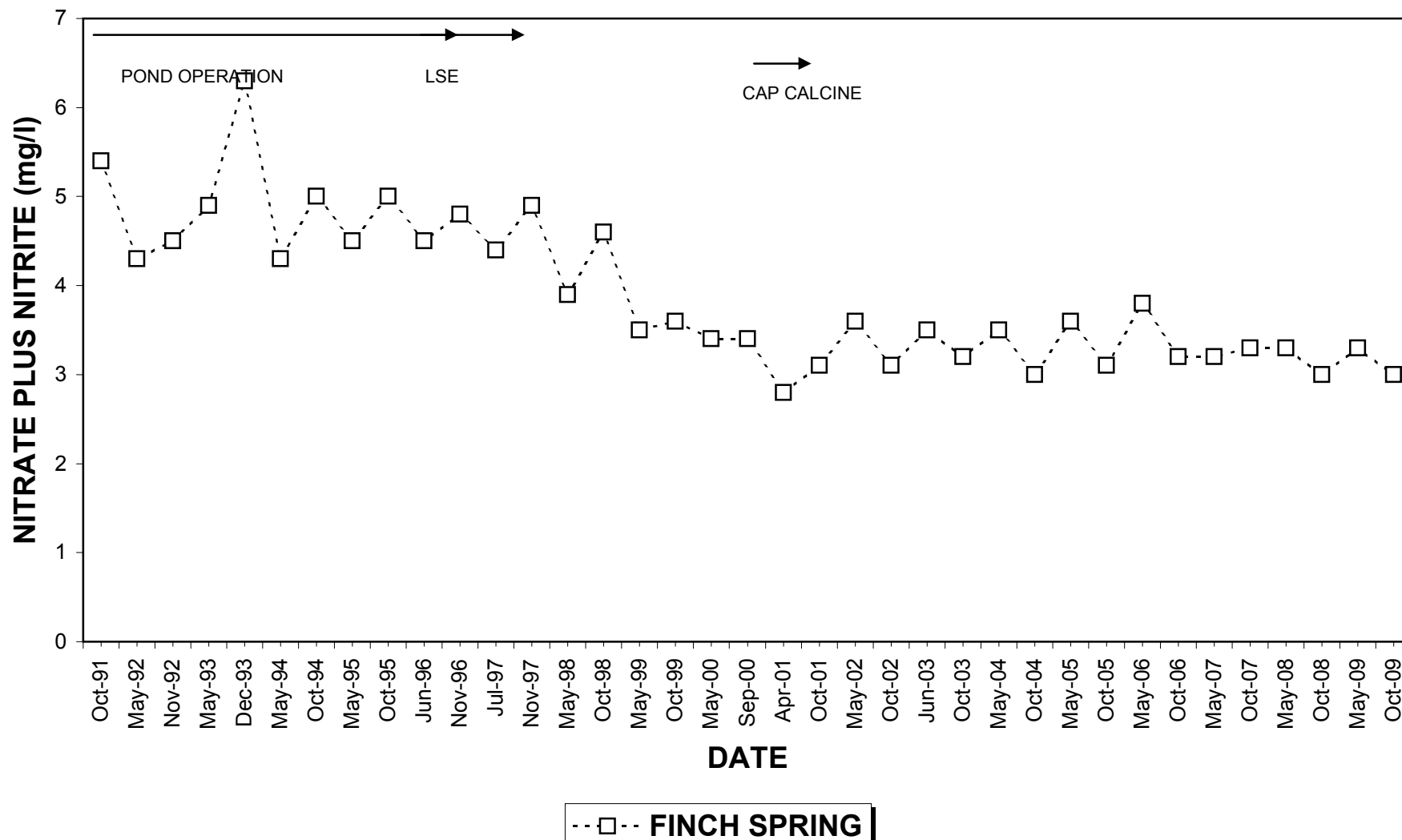
--◇-- KM-5 --□-- KM-6 --+-- KM-7 --△-- KM-9 --×-- KM-12 --\*-- KM-13 --○-- KM-19



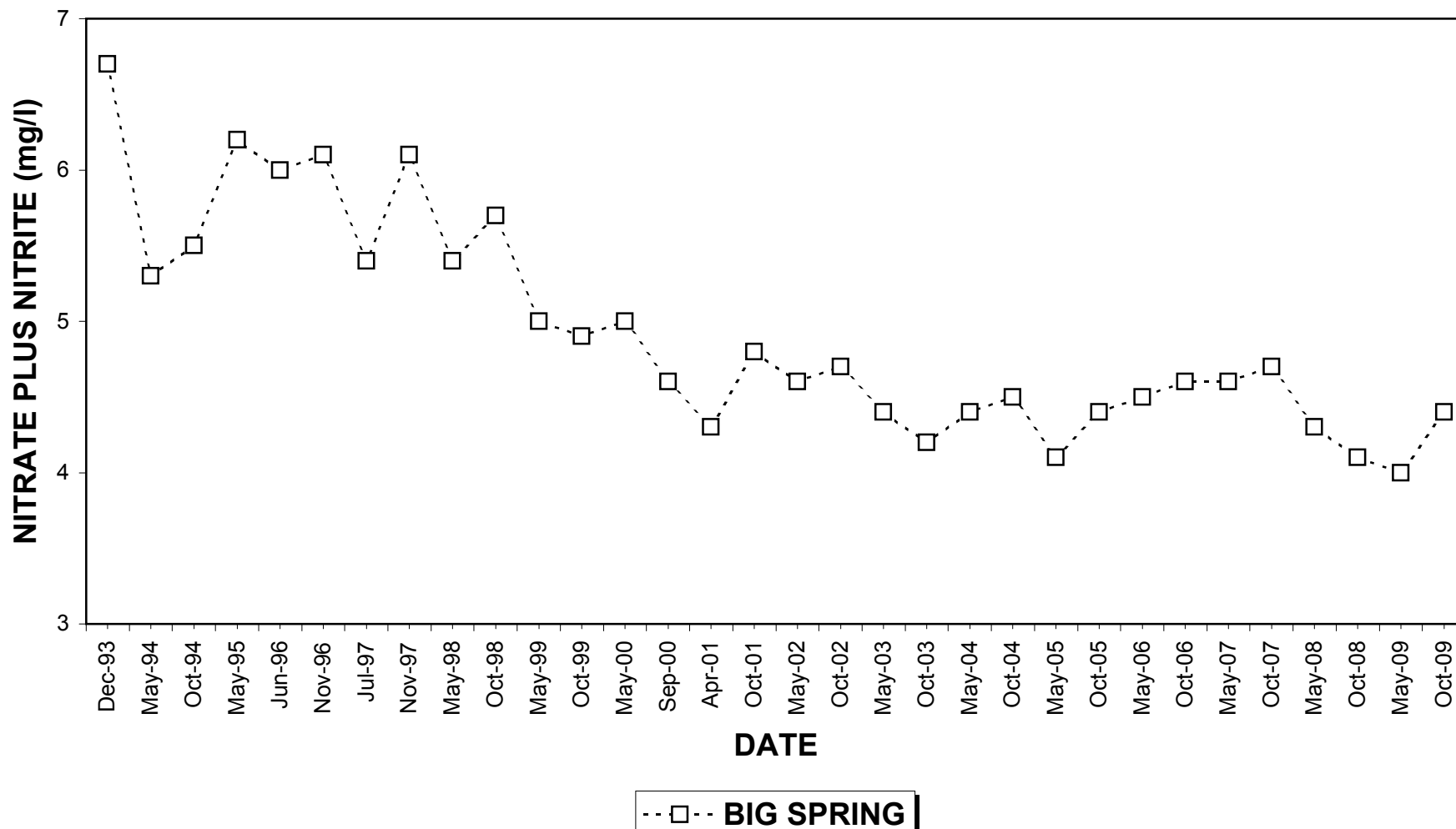
## NITRATE PLUS NITRITE VS TIME OFF-SITE WELLS



## NITRATE PLUS NITRITE VS TIME FINCH SPRING

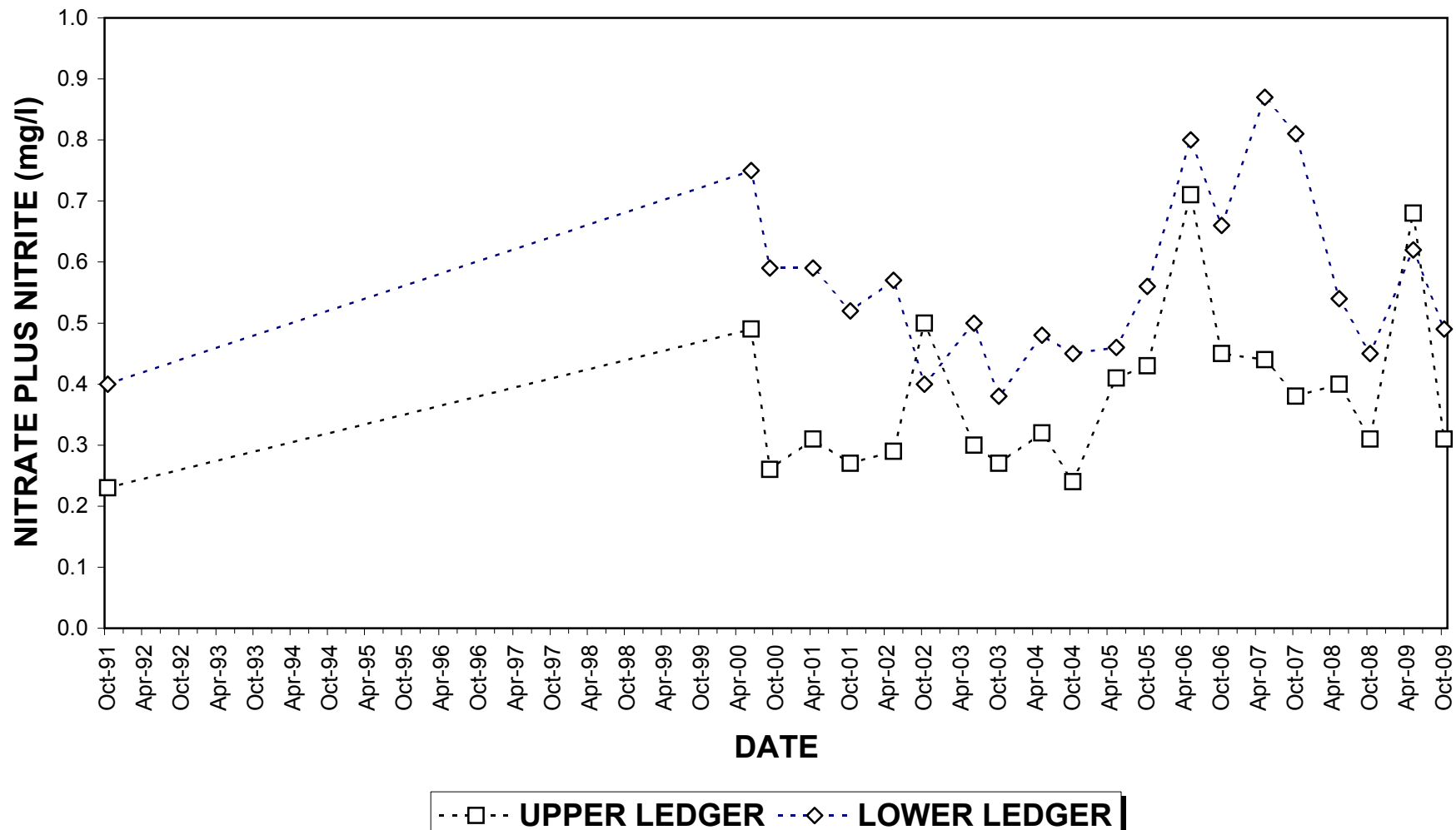


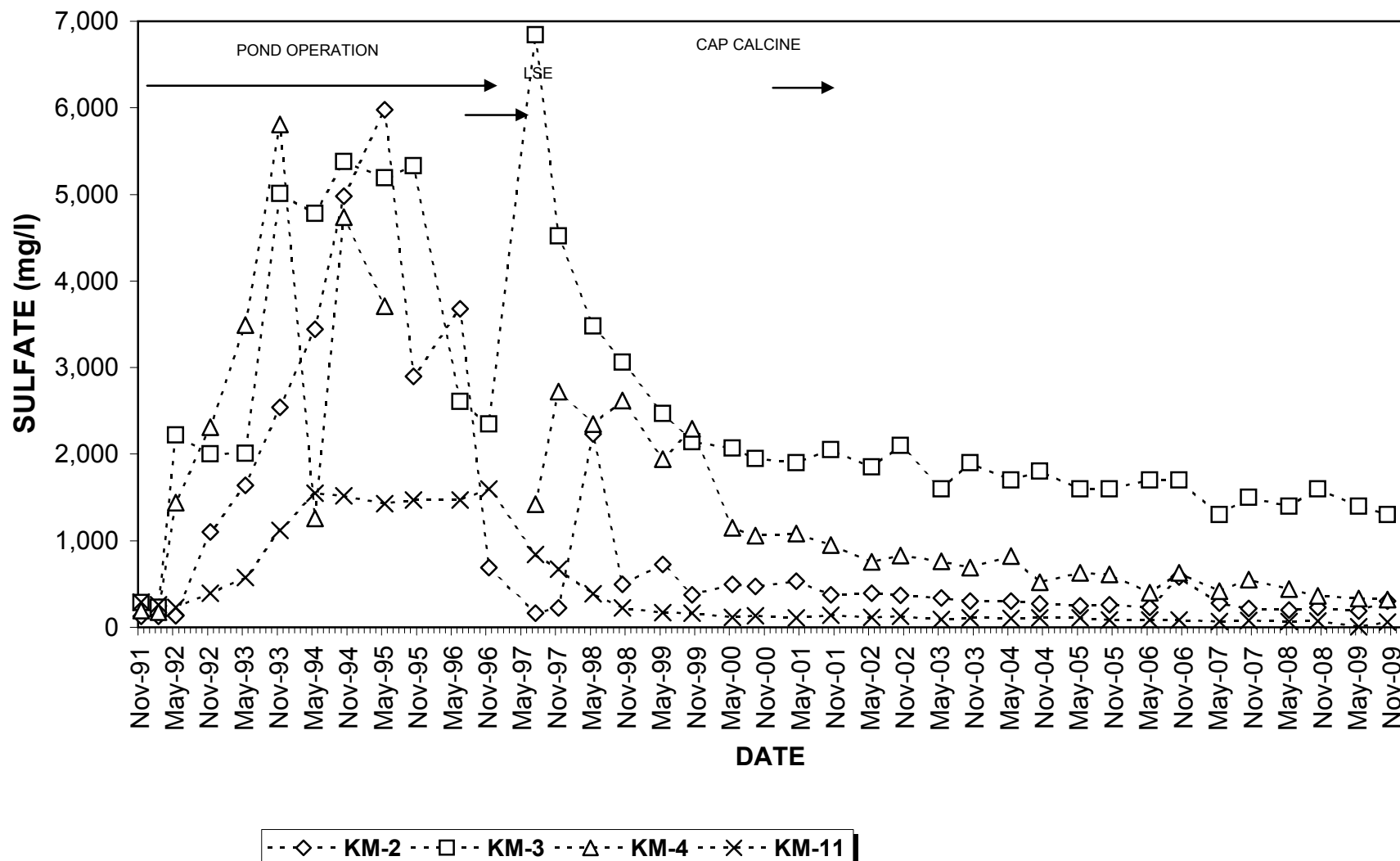
## NITRATE PLUS NITRITE VS TIME BIG SPRING

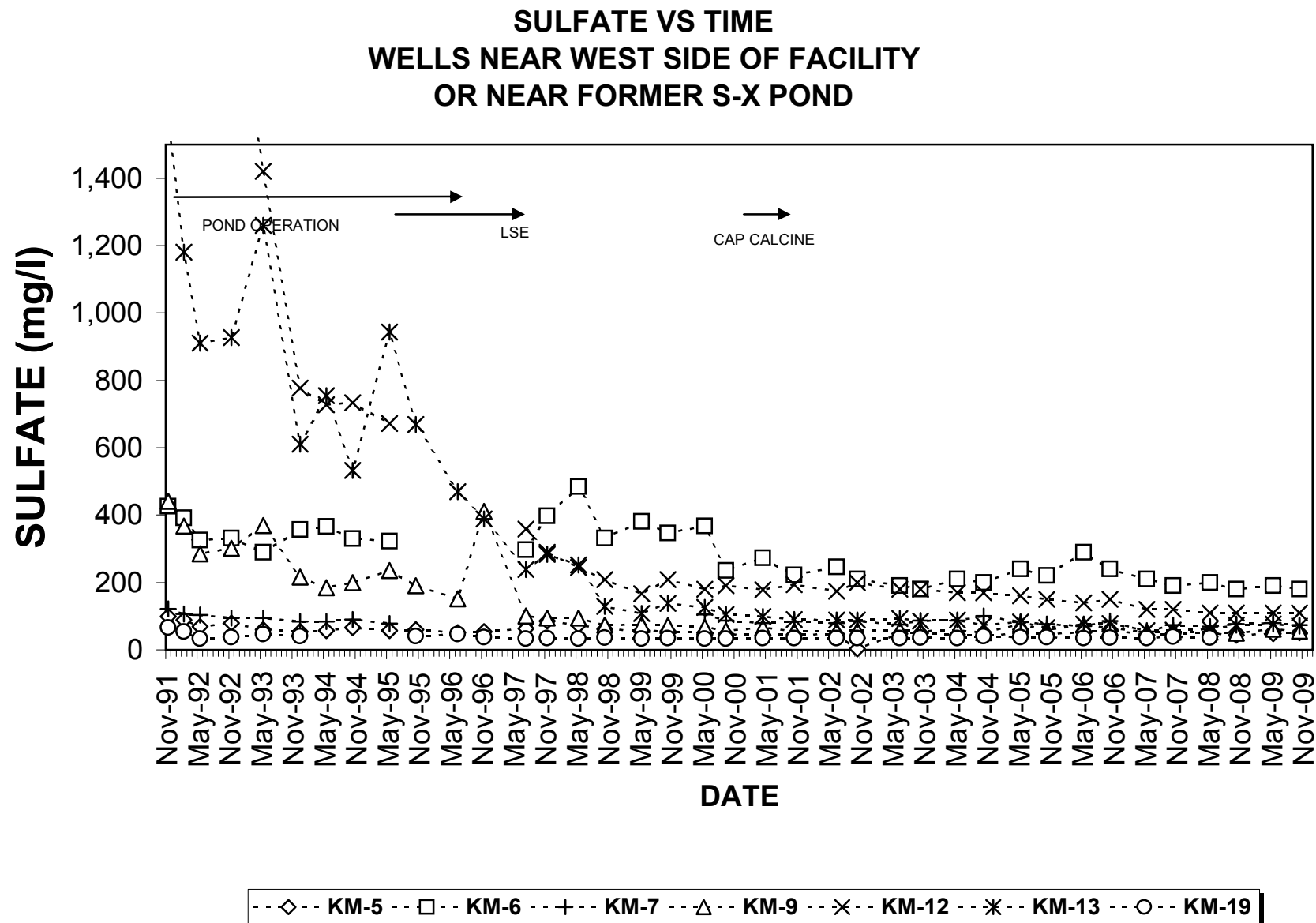




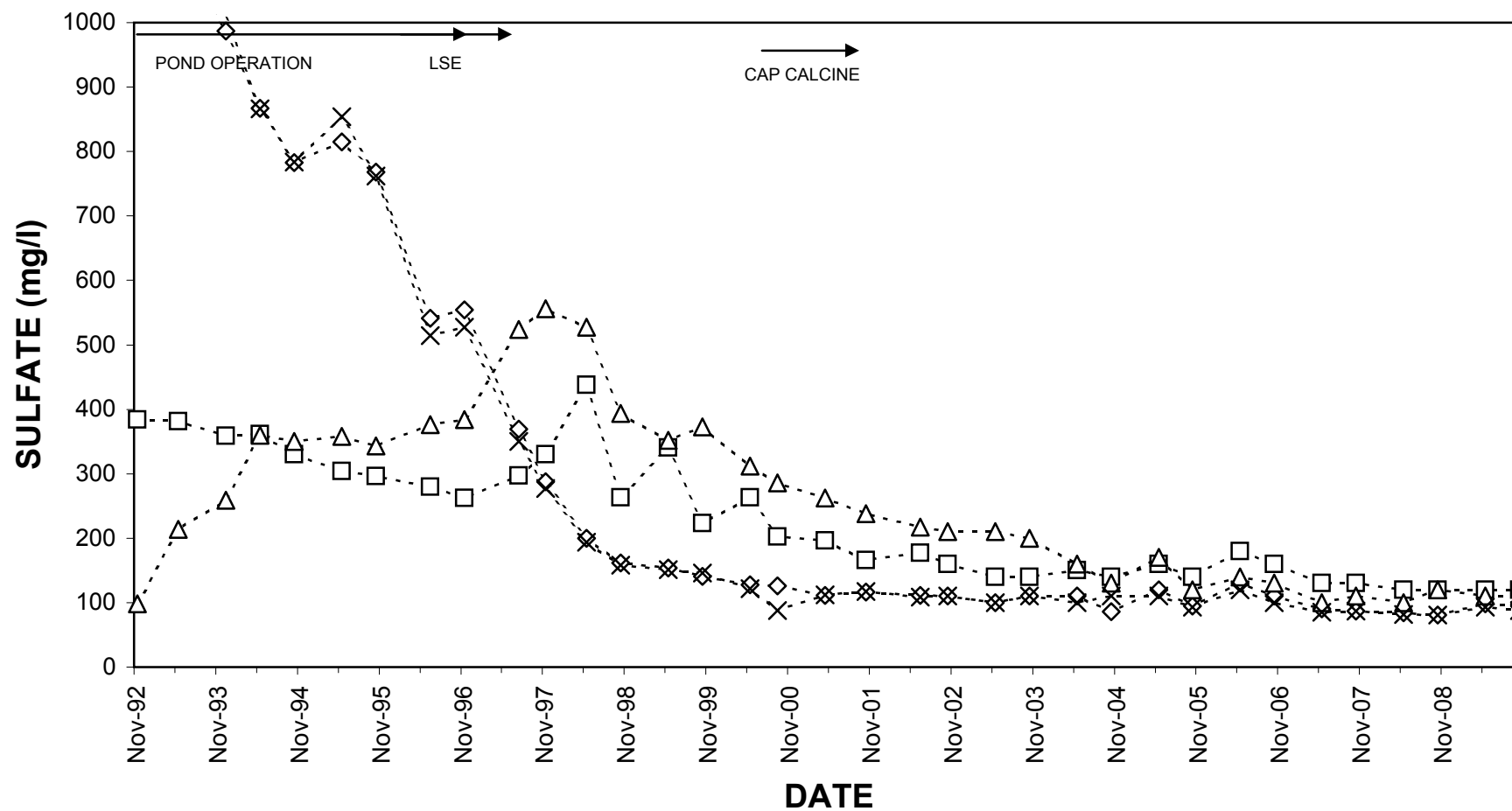
## NITRATE PLUS NITRITE VS TIME UPPER AND LOWER LEDGER SPRINGS



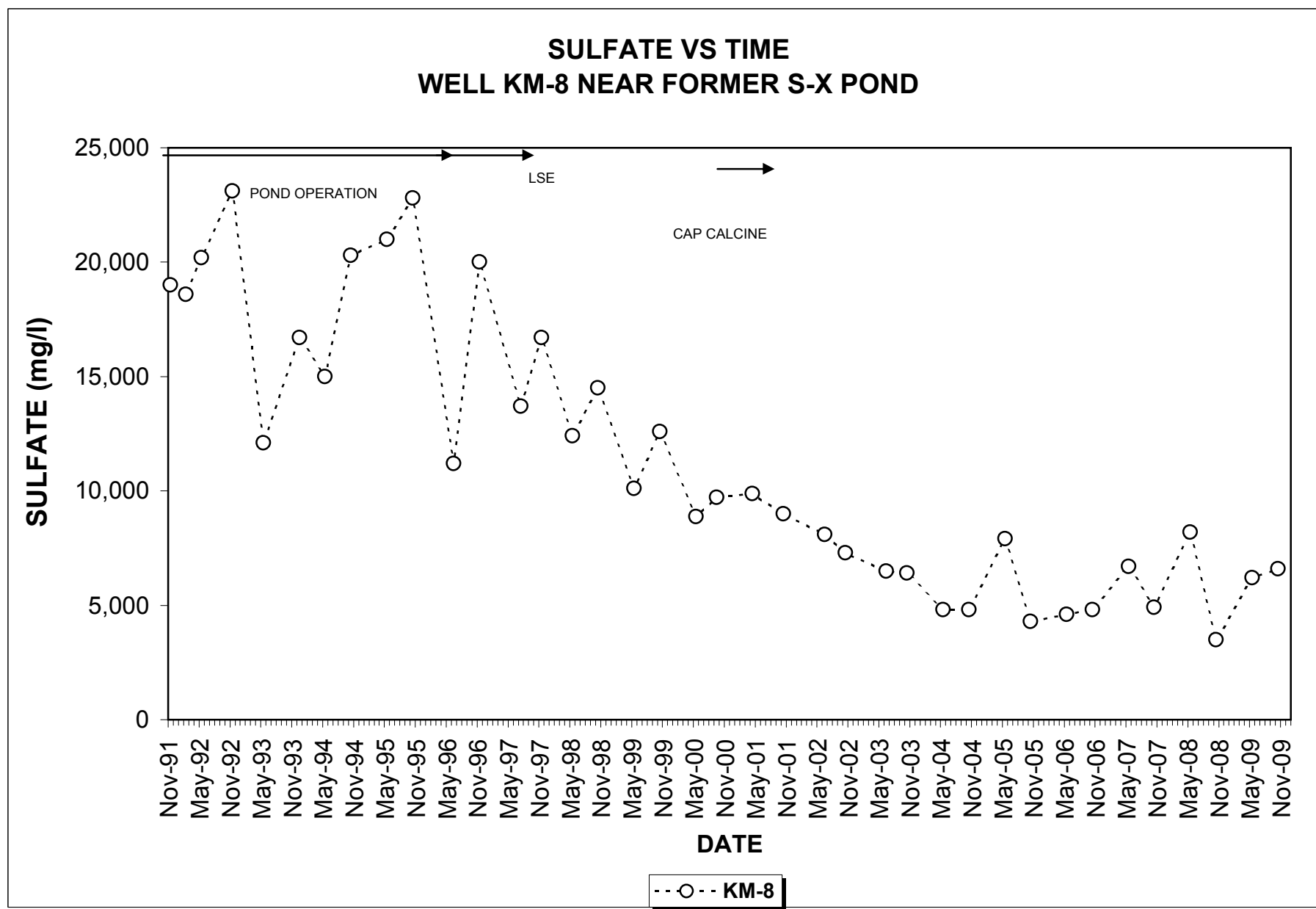
**SULFATE VS TIME  
WELLS NEAR FORMER SCRUBBER POND**



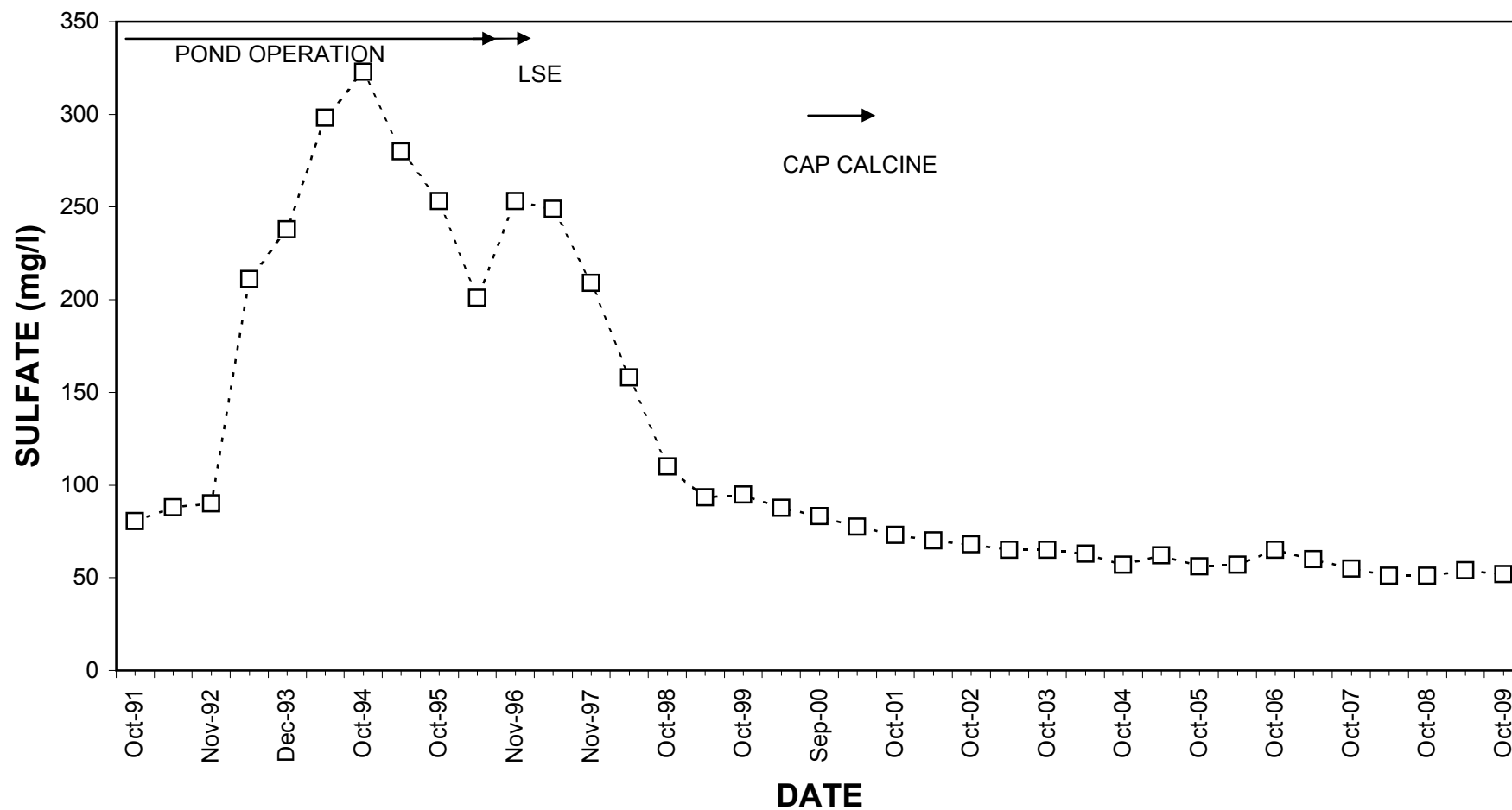
## SULFATE VS TIME OFF-SITE WELLS



---◇--- KM-15 ---□--- KM-16 ---△--- KM-17 ---×--- KM-18

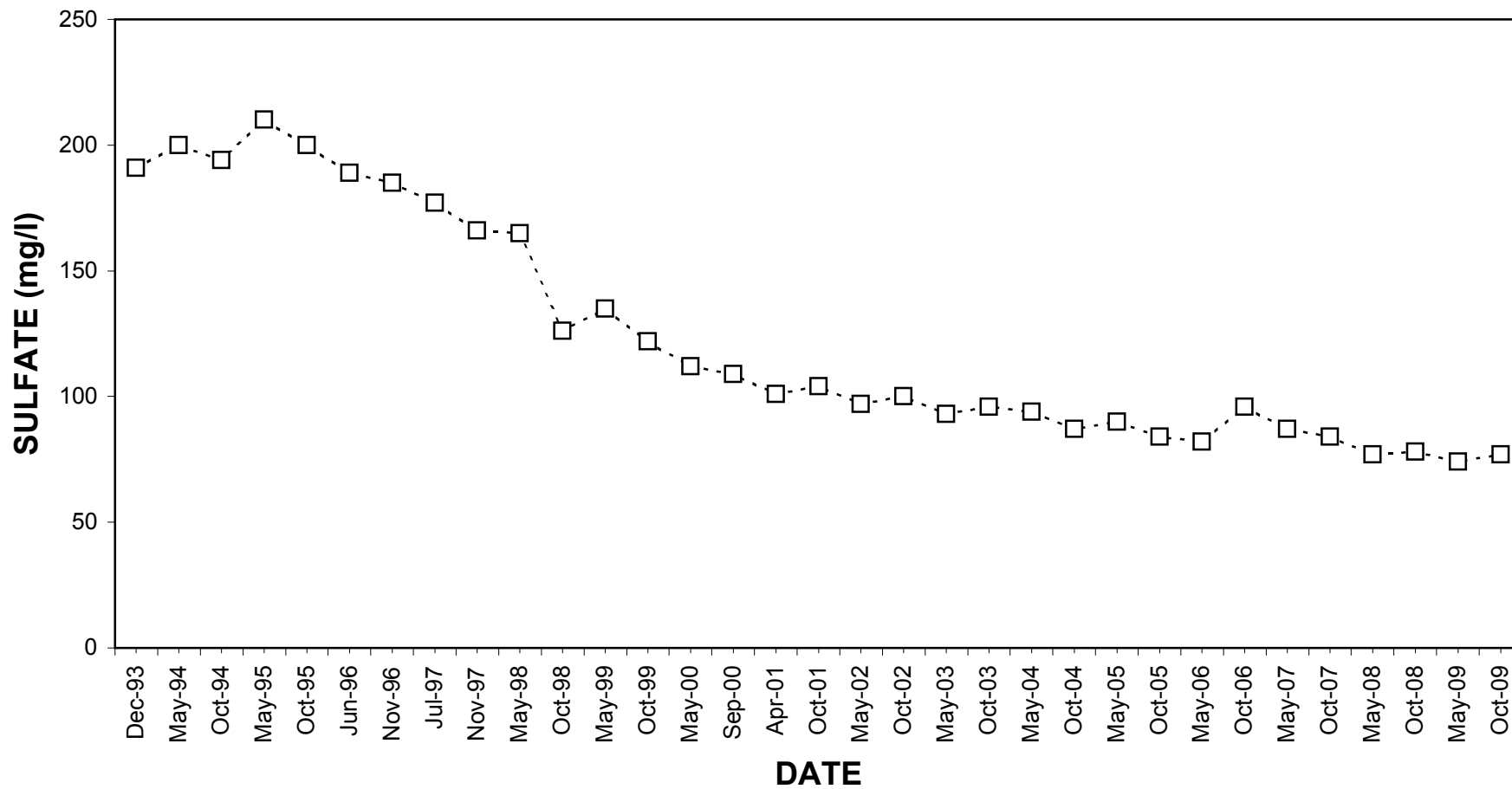


## SULFATE VS TIME FINCH SPRING



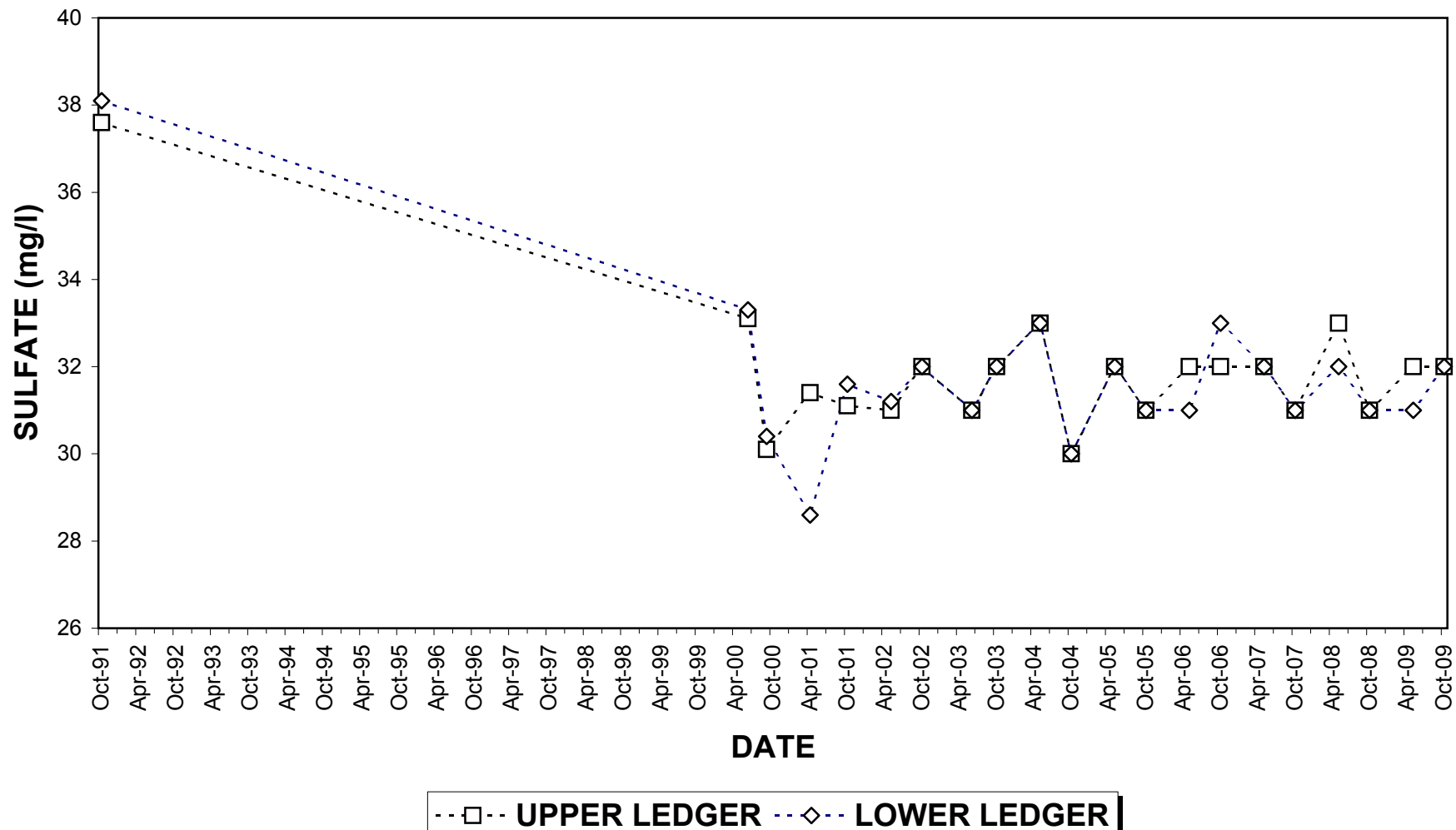
--□-- FINCH SPRING

## SULFATE VS TIME BIG SPRING

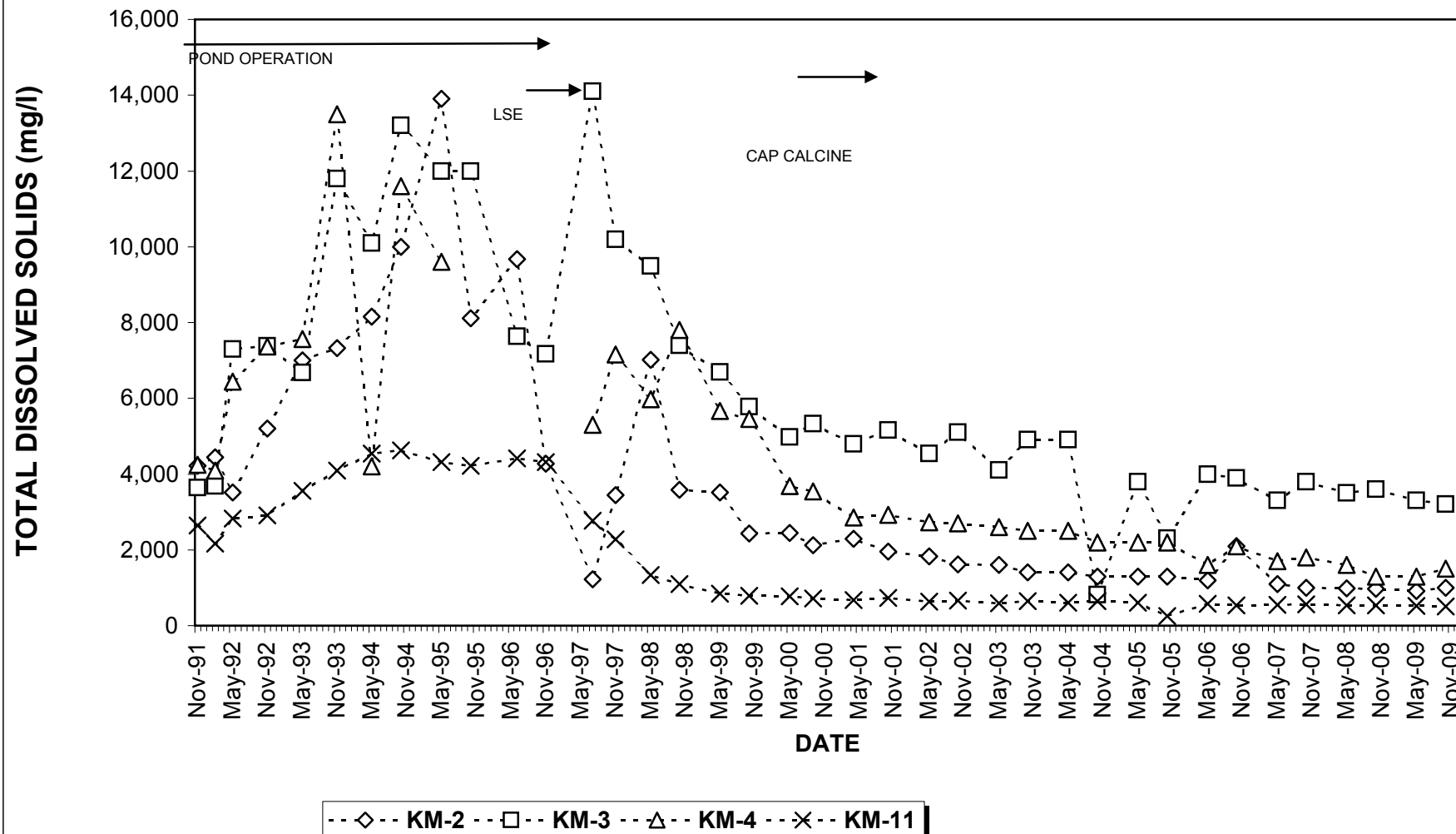


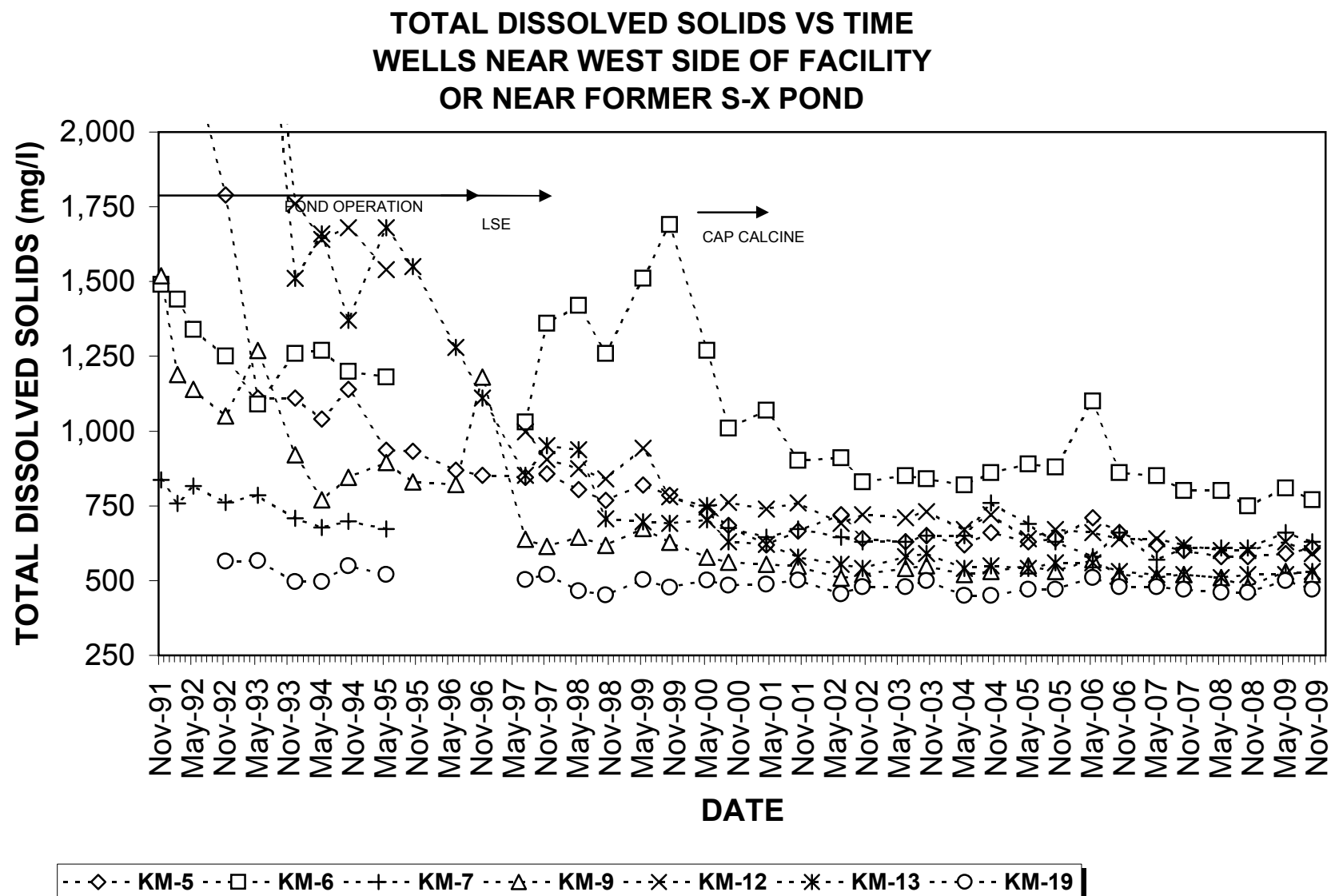
---□--- **BIG SPRING**

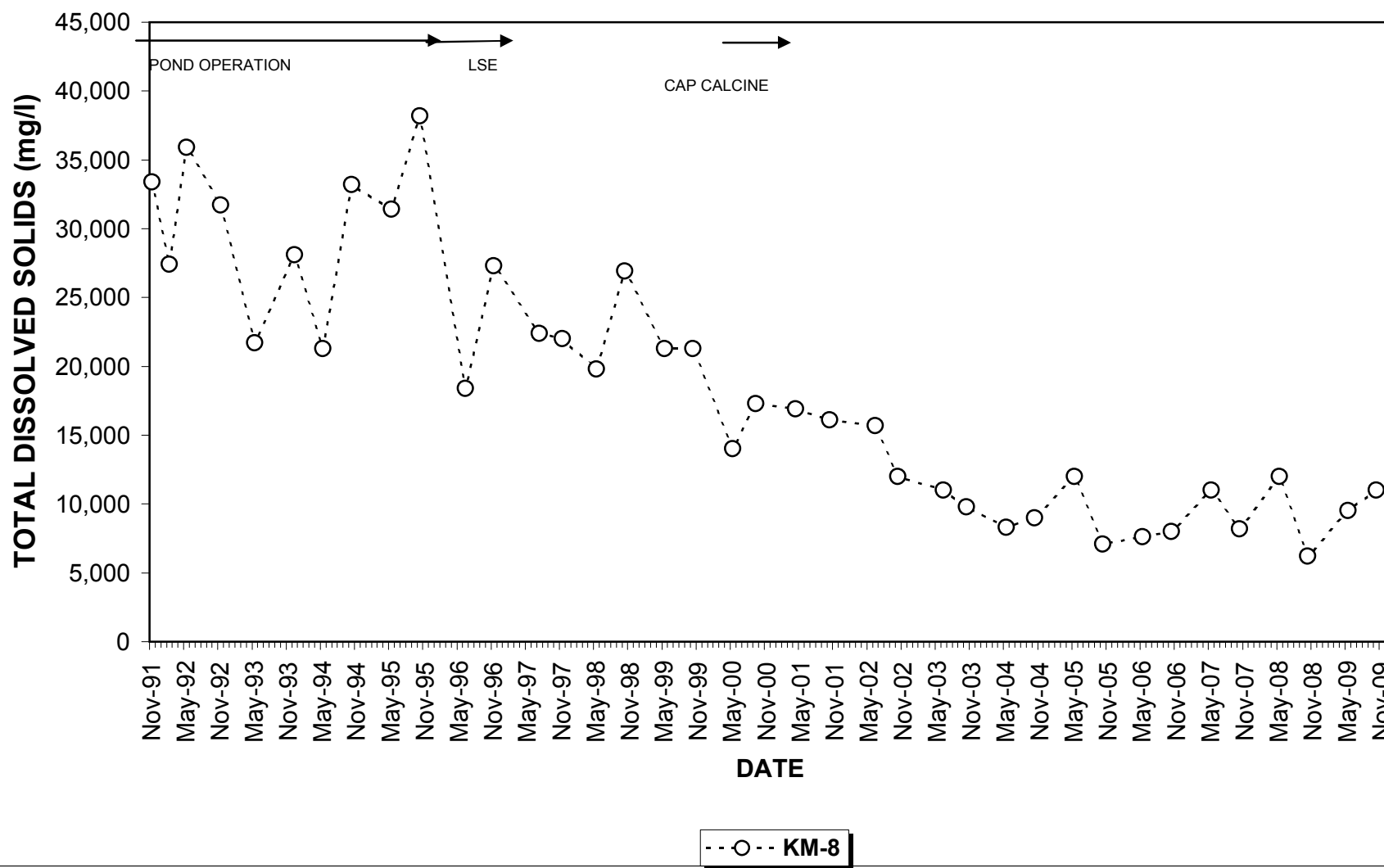
## SULFATE VS TIME UPPER AND LOWER LEDGER SPRINGS

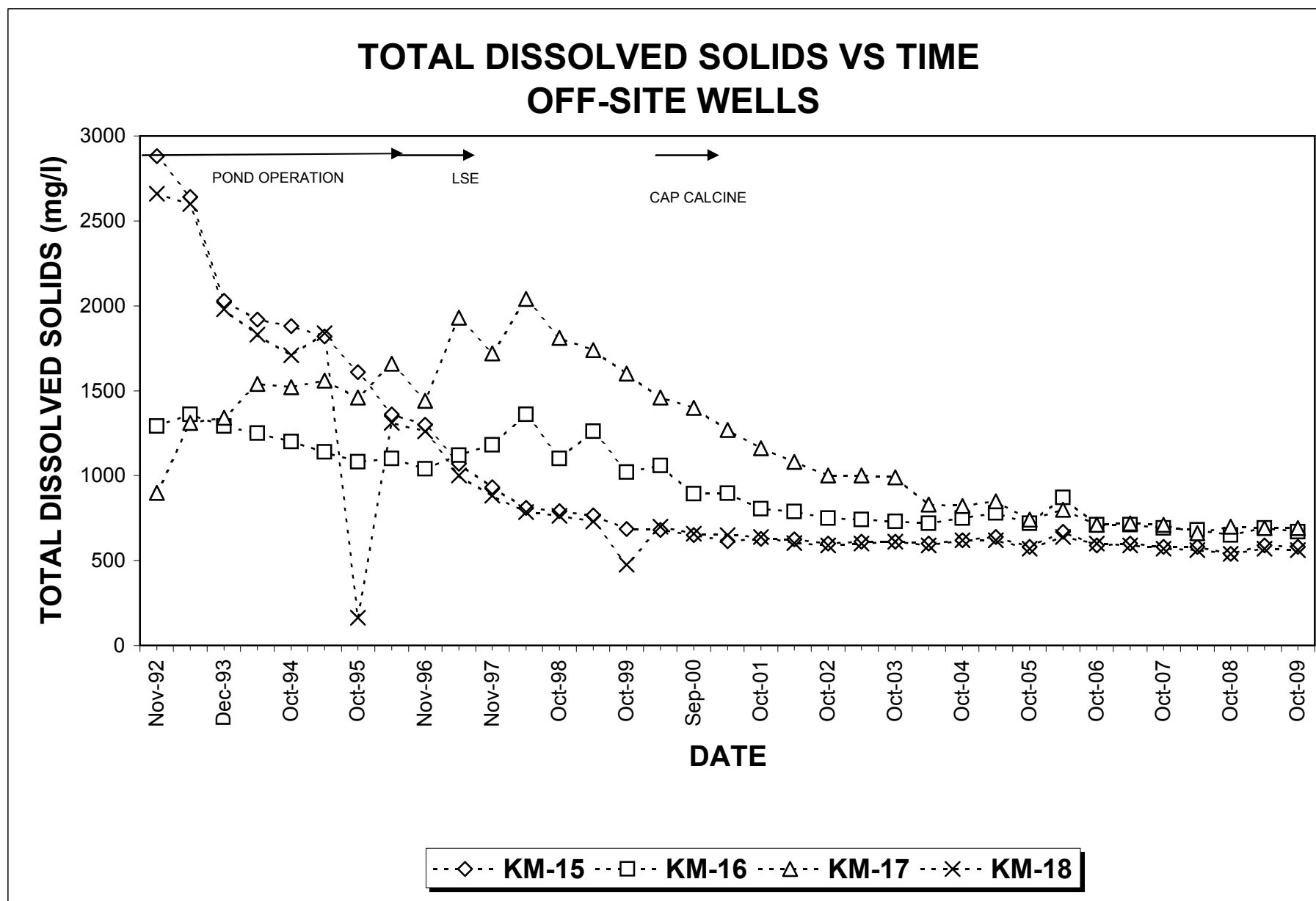


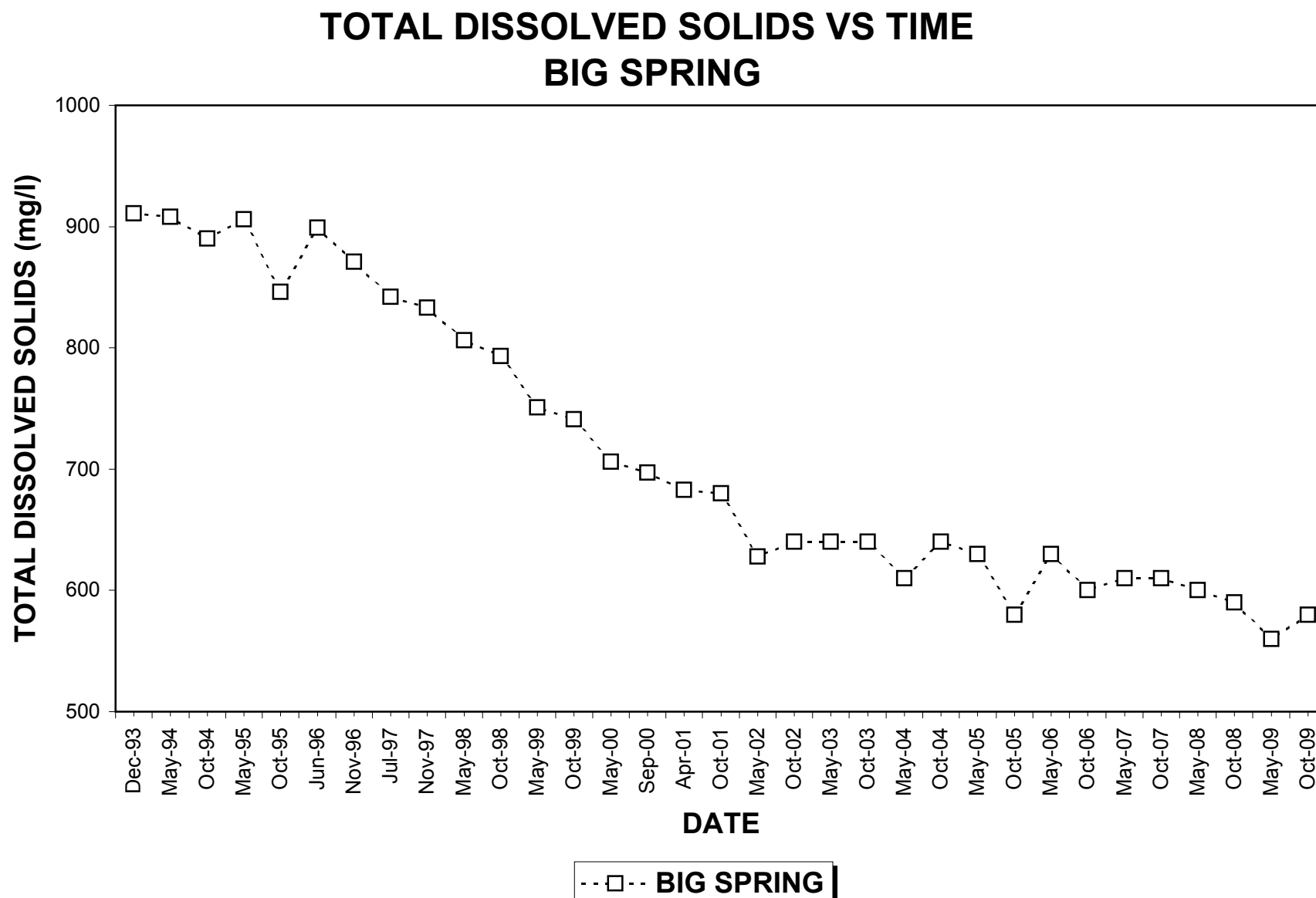


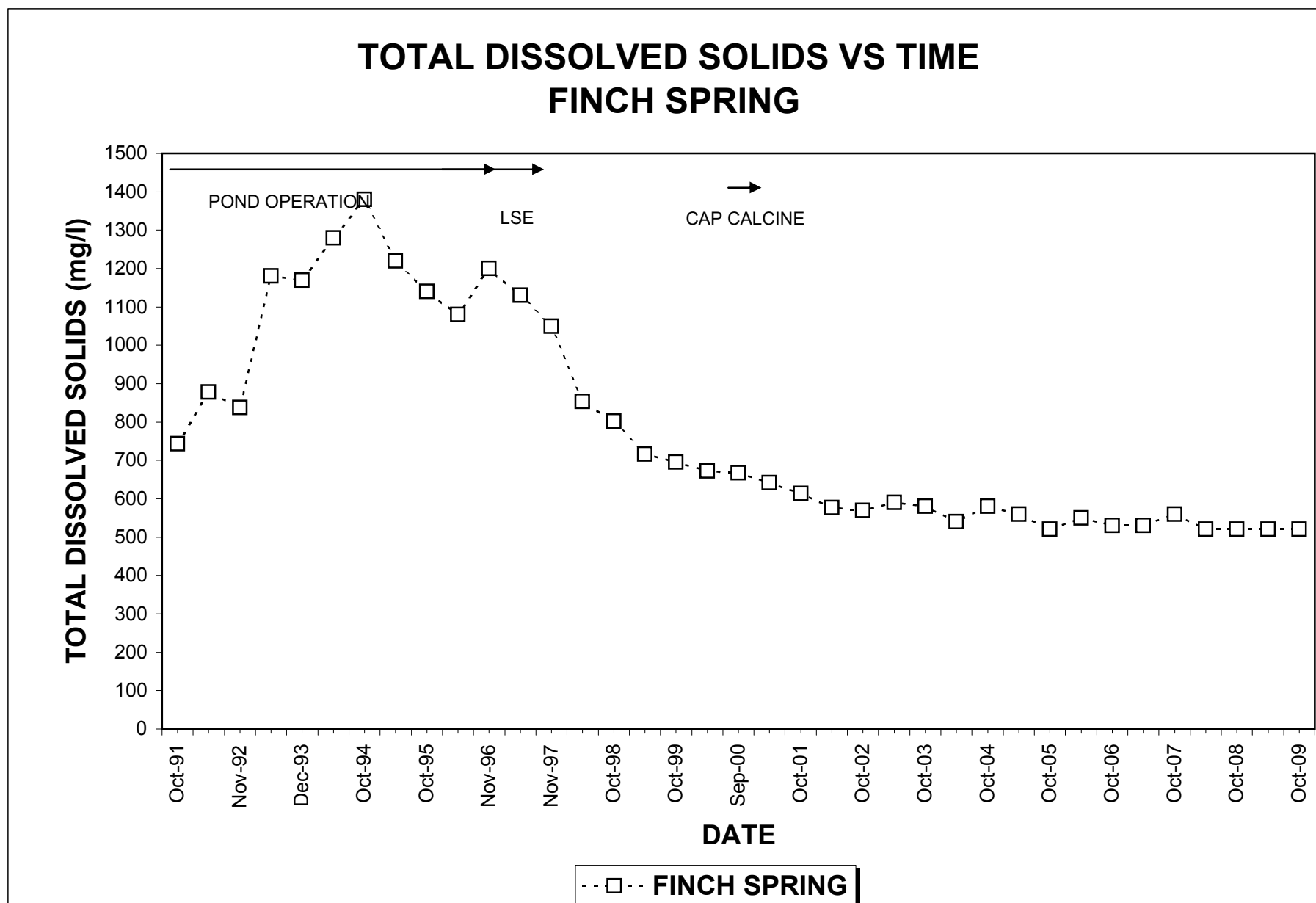
**TOTAL DISSOLVED SOLIDS VS TIME  
WELLS NEAR FORMER SCRUBBER POND**



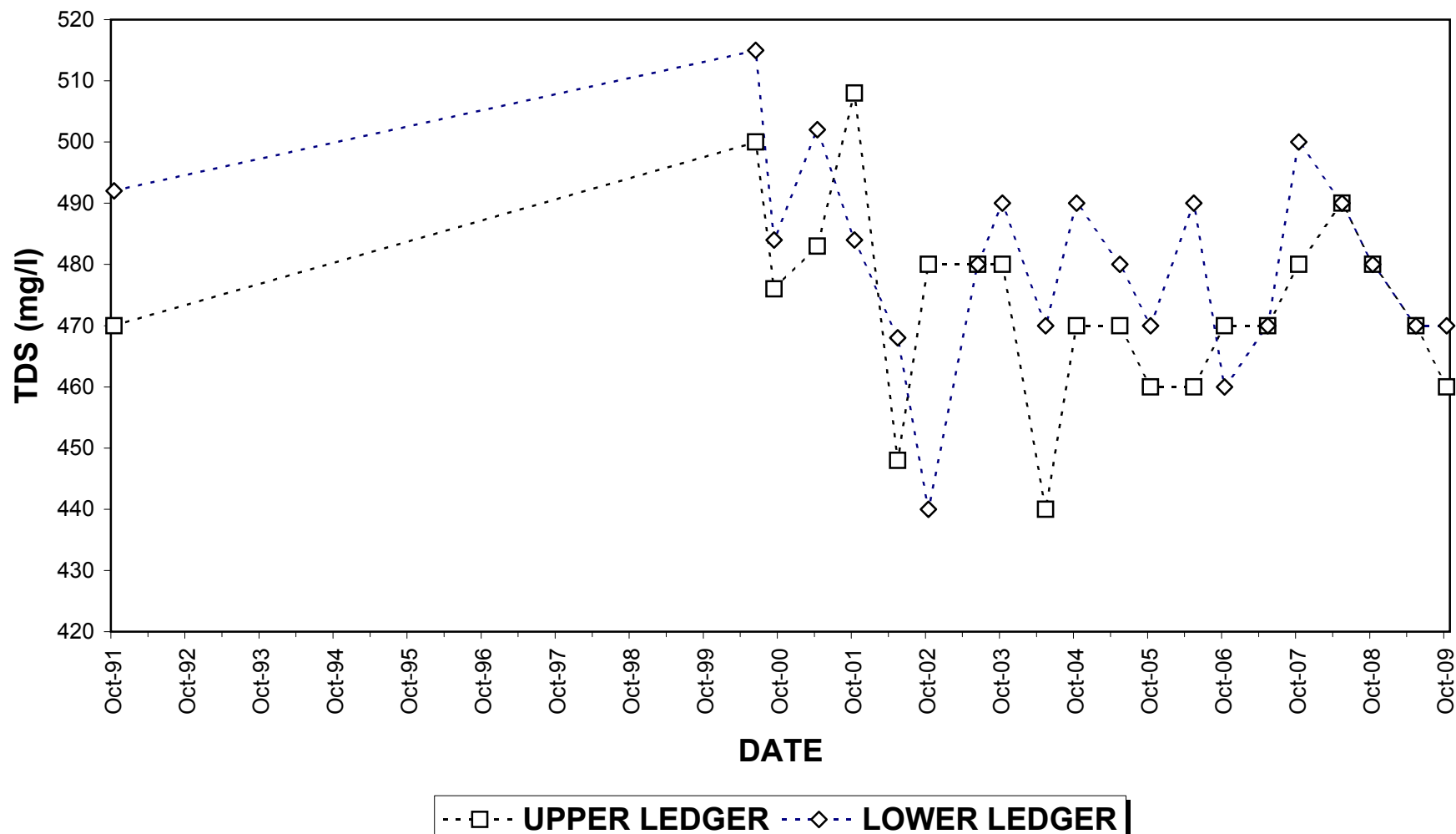
**TOTAL DISSOLVED SOLIDS VS TIME  
WELL KM-8 NEAR FORMER S-X POND**

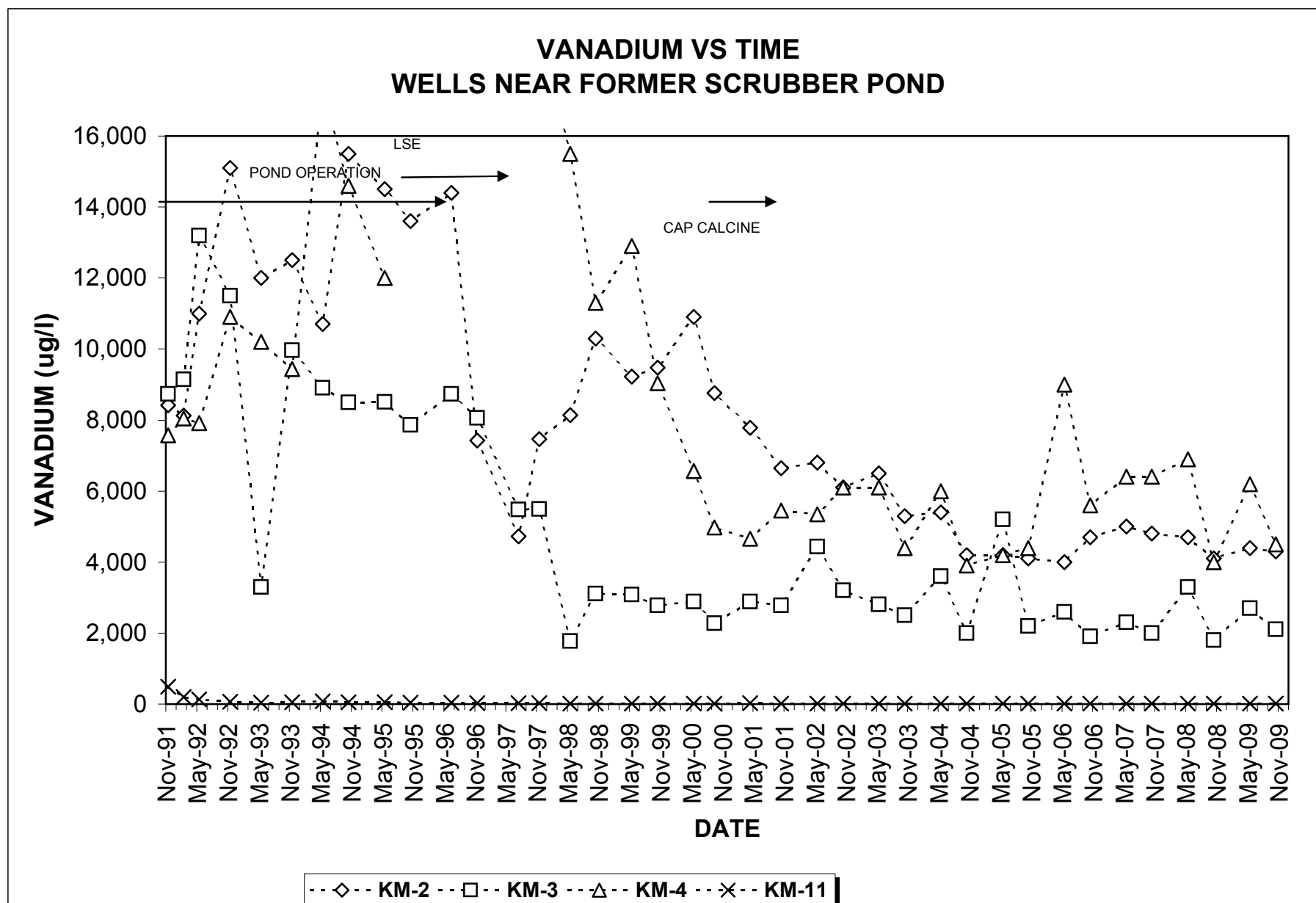






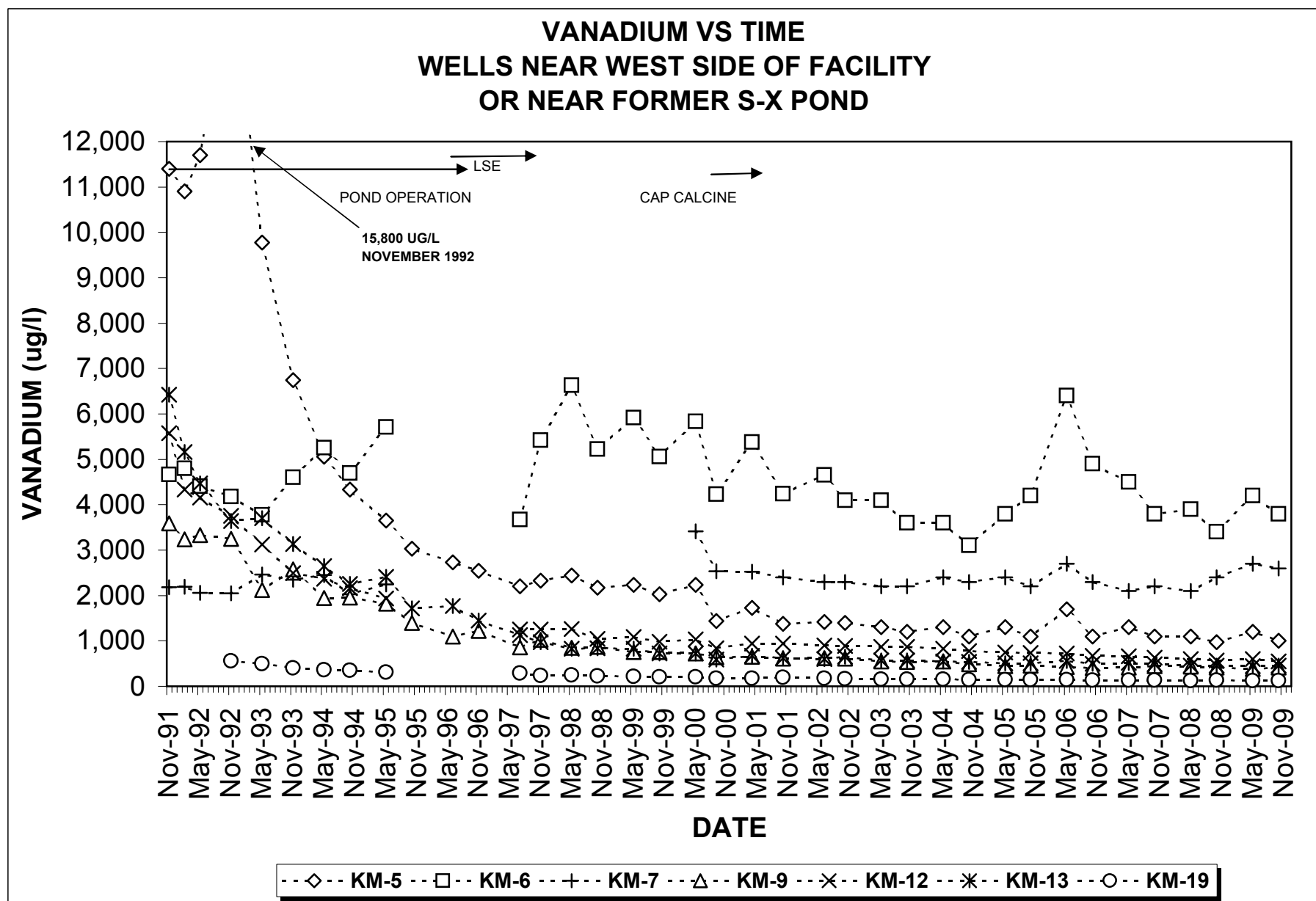
## TDS VS TIME UPPER AND LOWER LEDGER SPRINGS





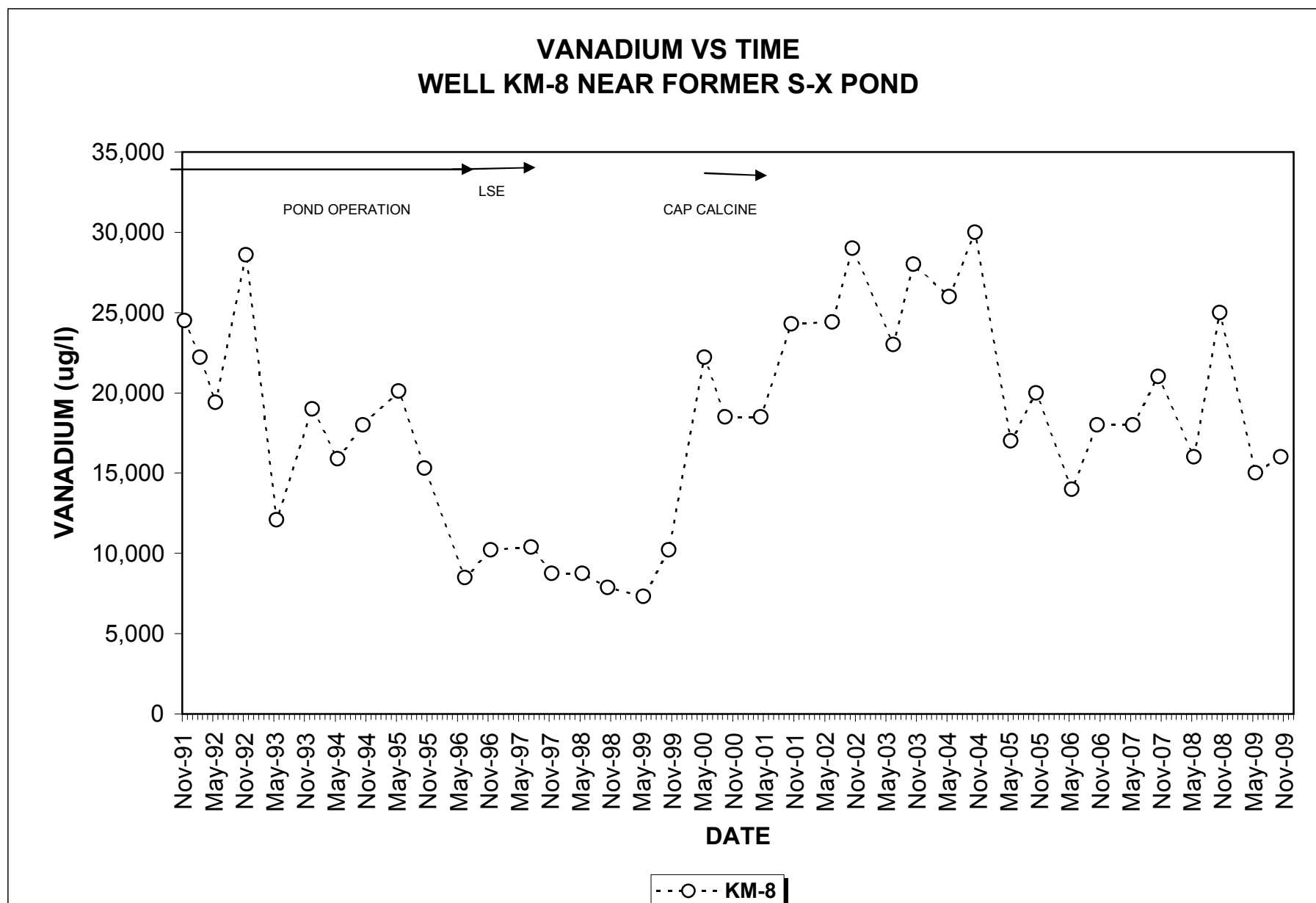
RBC FOR VANADIUM IS 260 ug/l  
KM-2, KM-3, KM-11 ARE POC WELLS



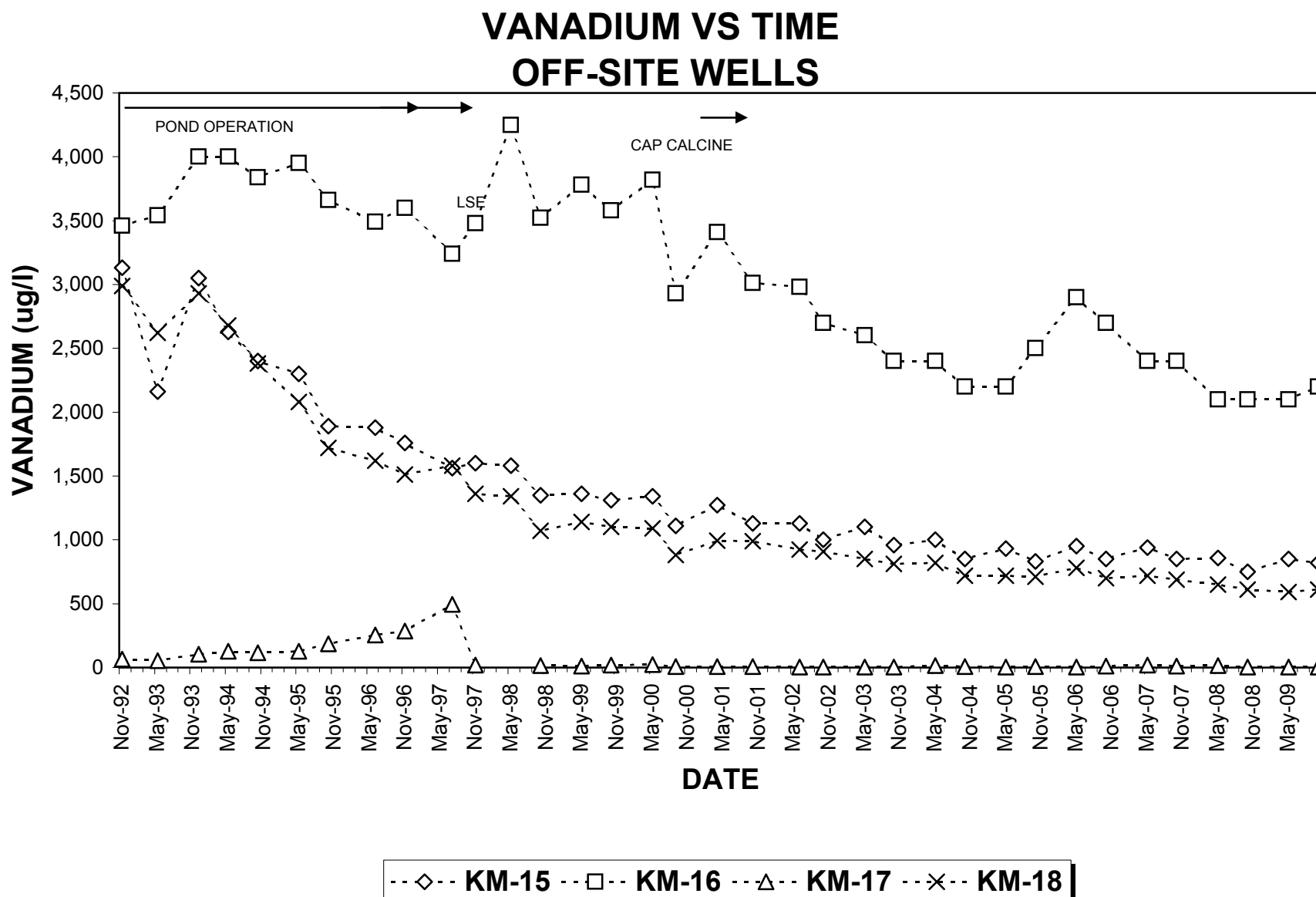


RBC FOR VANADIUM IS 260 ug/l

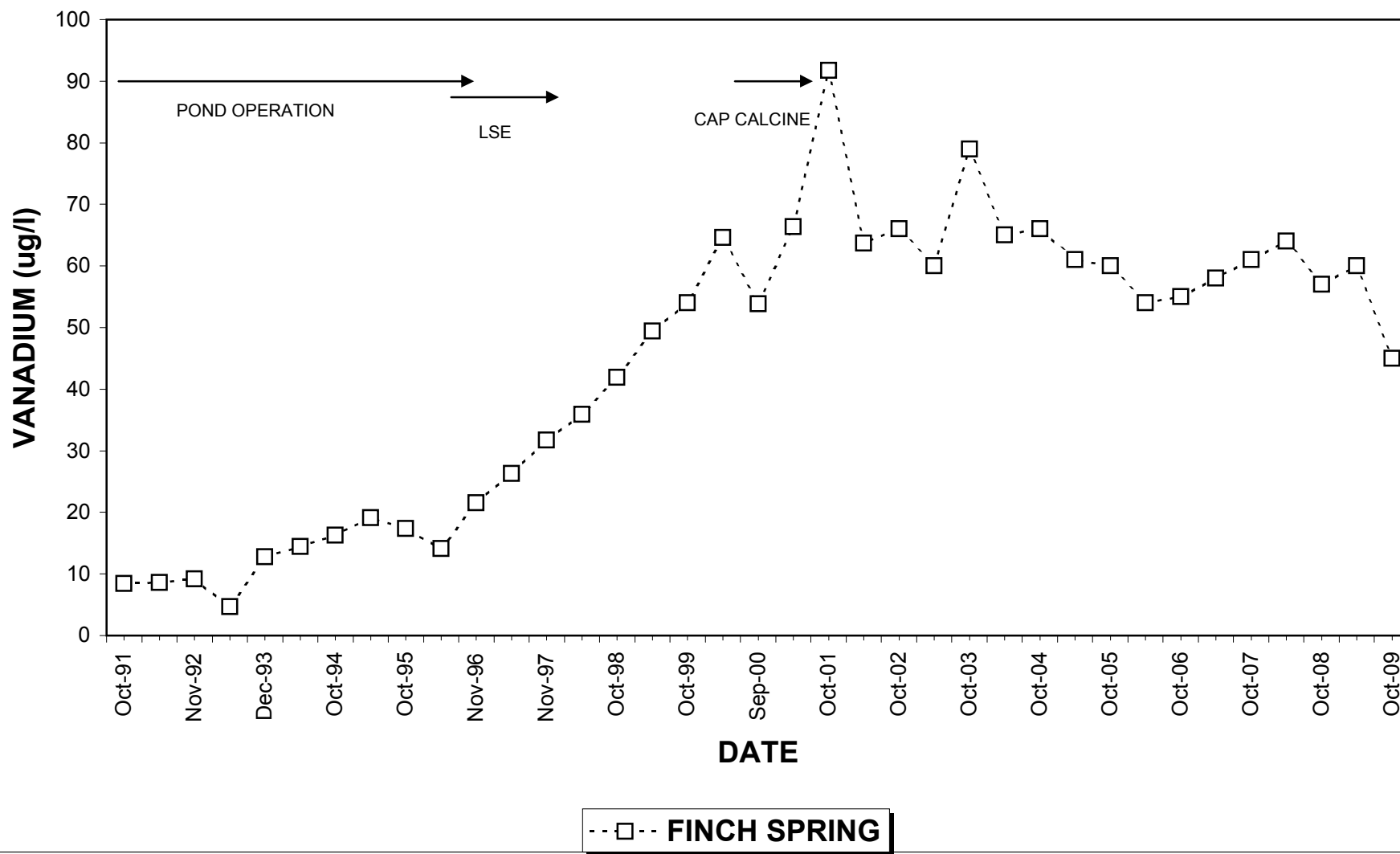
KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

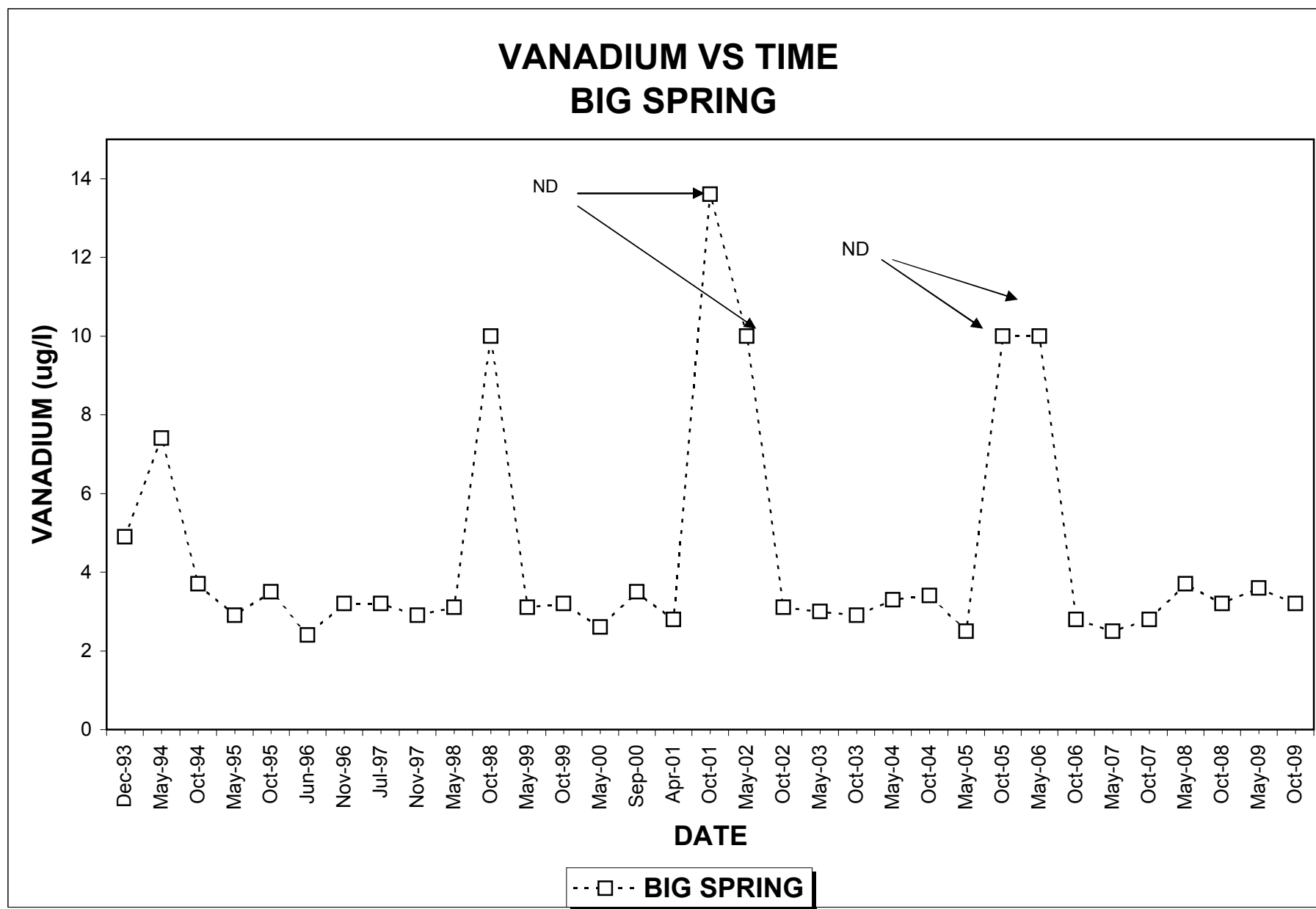


RBC FOR VANADIUM IS 260 ug/l  
KM-8 IS A POC WELLS

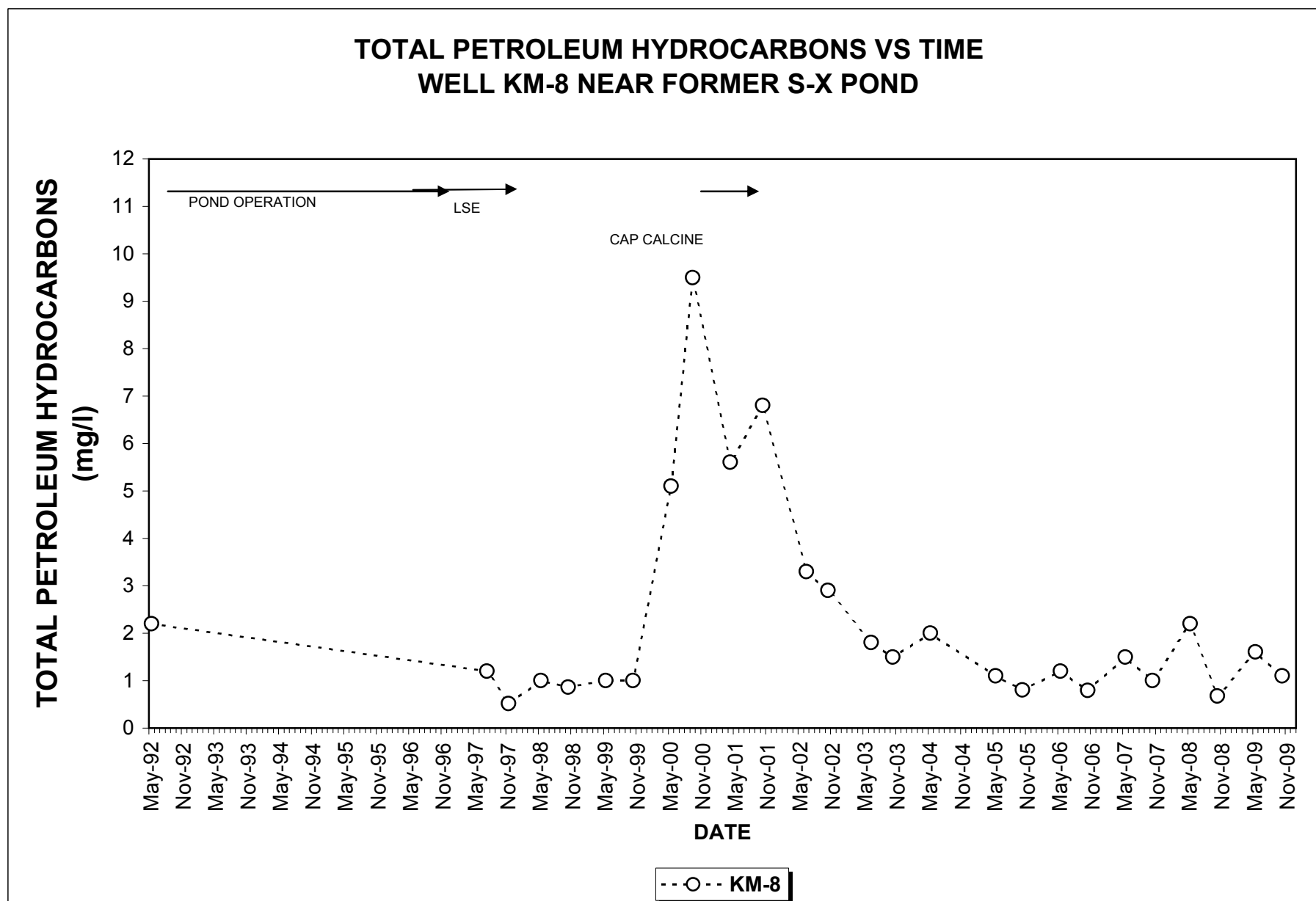


## VANADIUM VS TIME FINCH SPRING





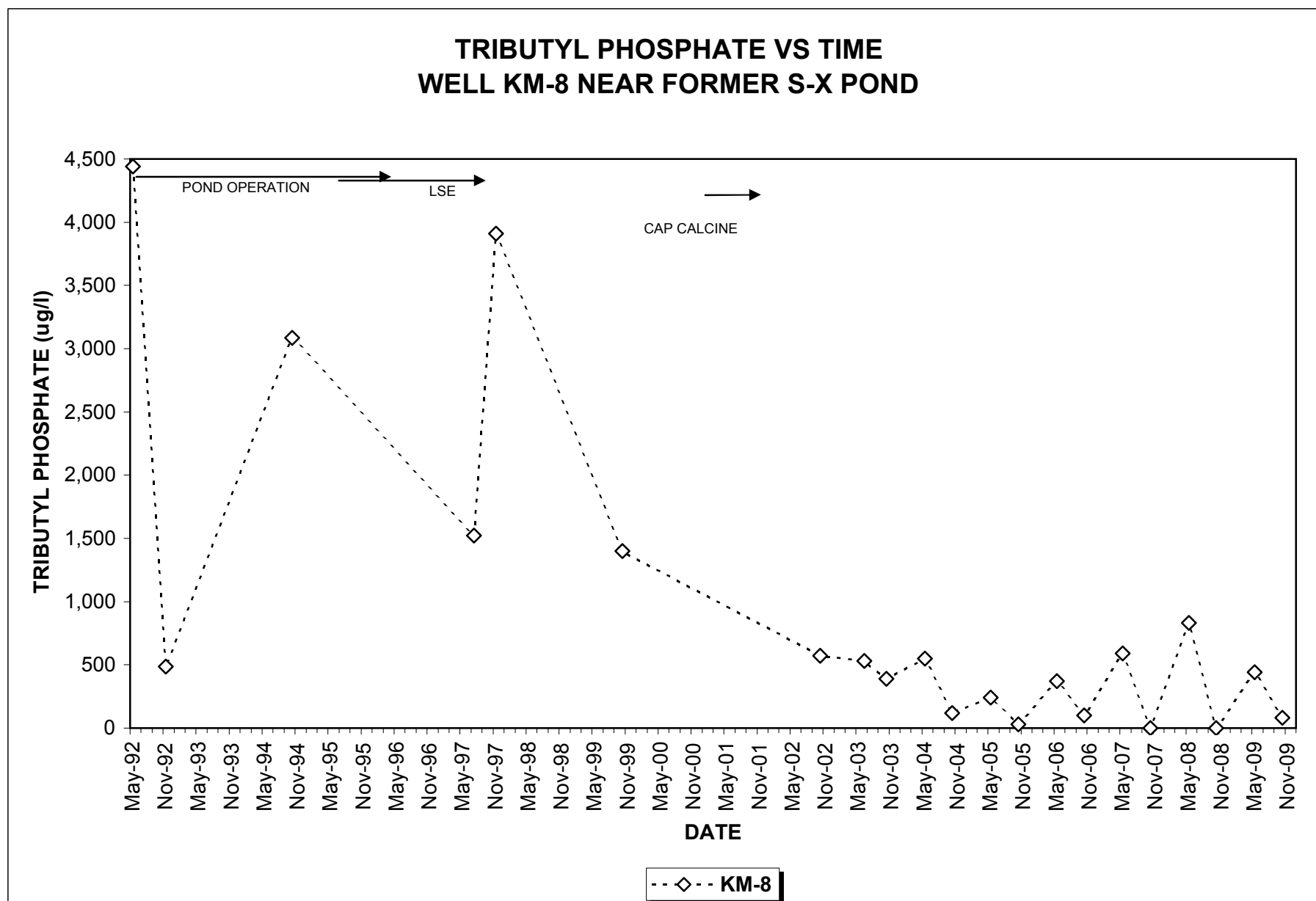
Values less than detection annotated on figure



RBC FOR TPH IS 0.73 mg/l

KM-8 IS A POC WELL

1999 VALUES LESS THAN DETECTION

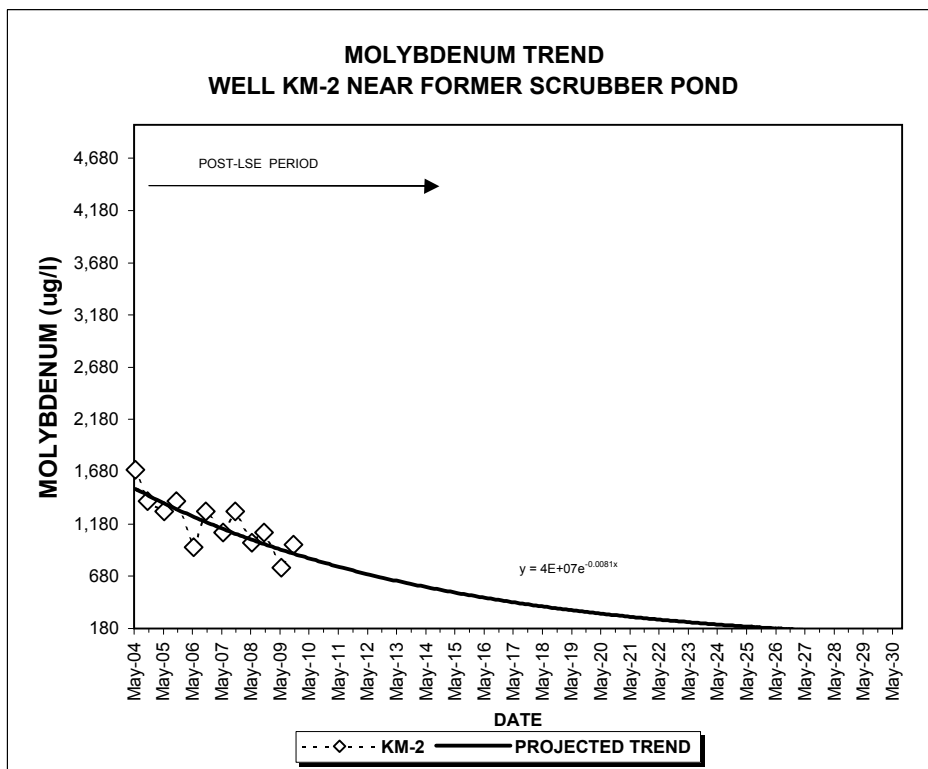
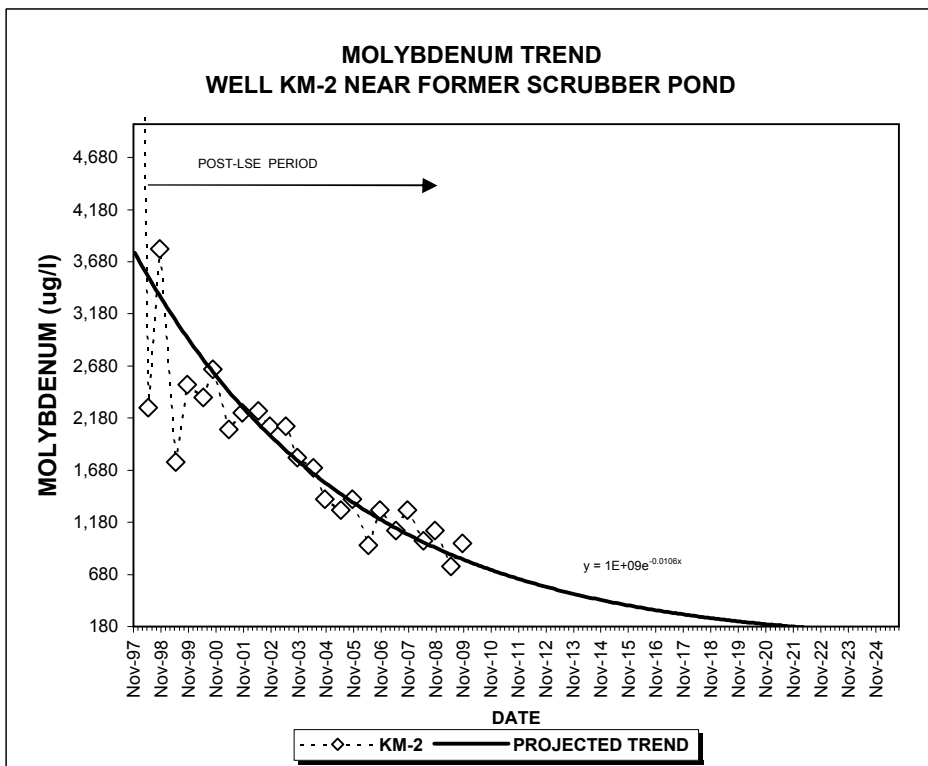


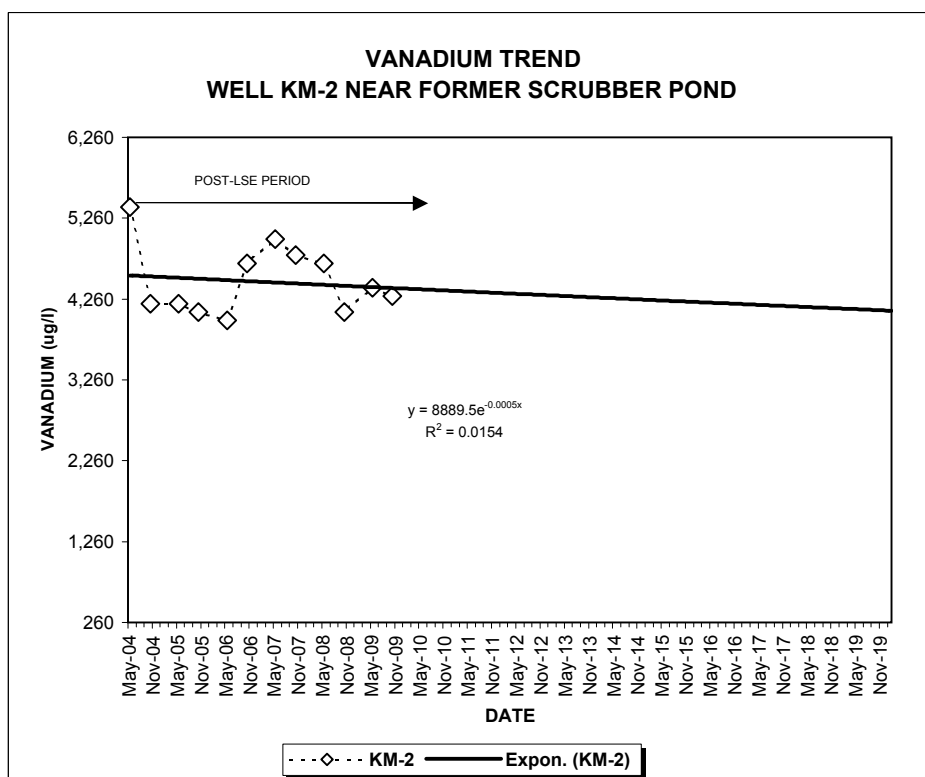
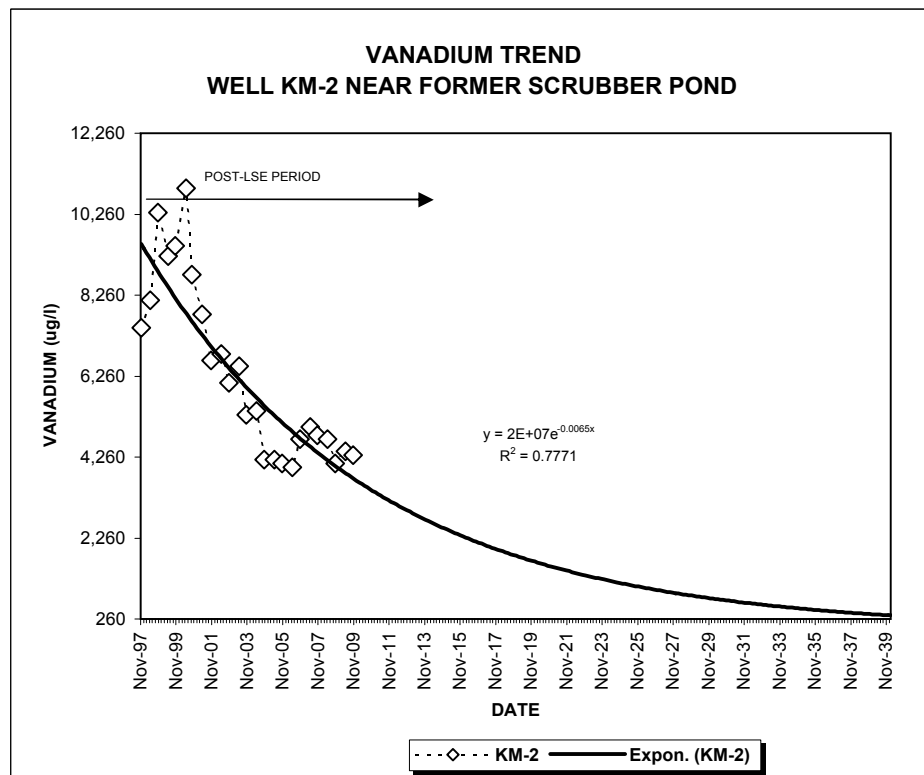
RBC FOR TRIBUTYL PHOSPHATE IS 180 ug/l  
KM-8 IS A POC WELL  
VALUES ESTIMATED AS DETECTED

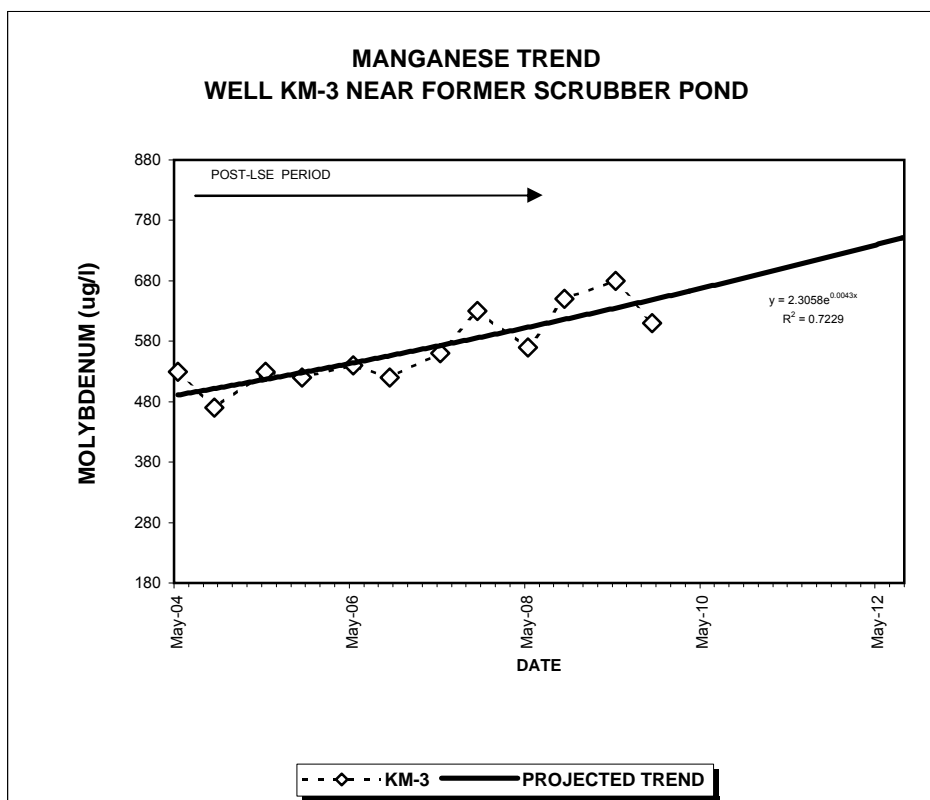
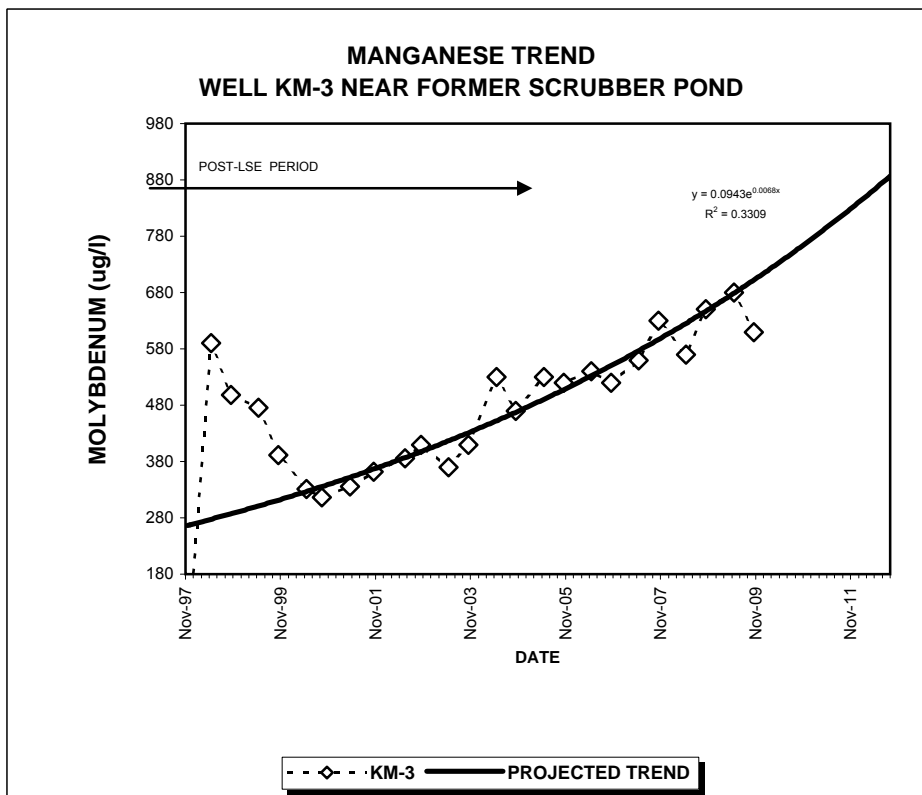
**APPENDIX B**

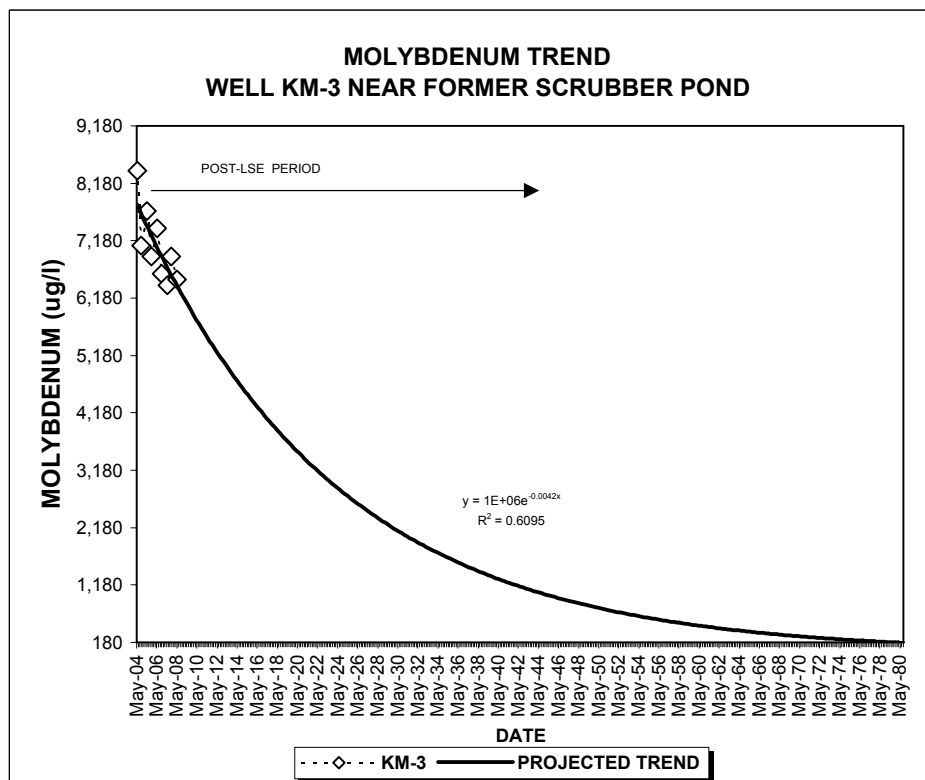
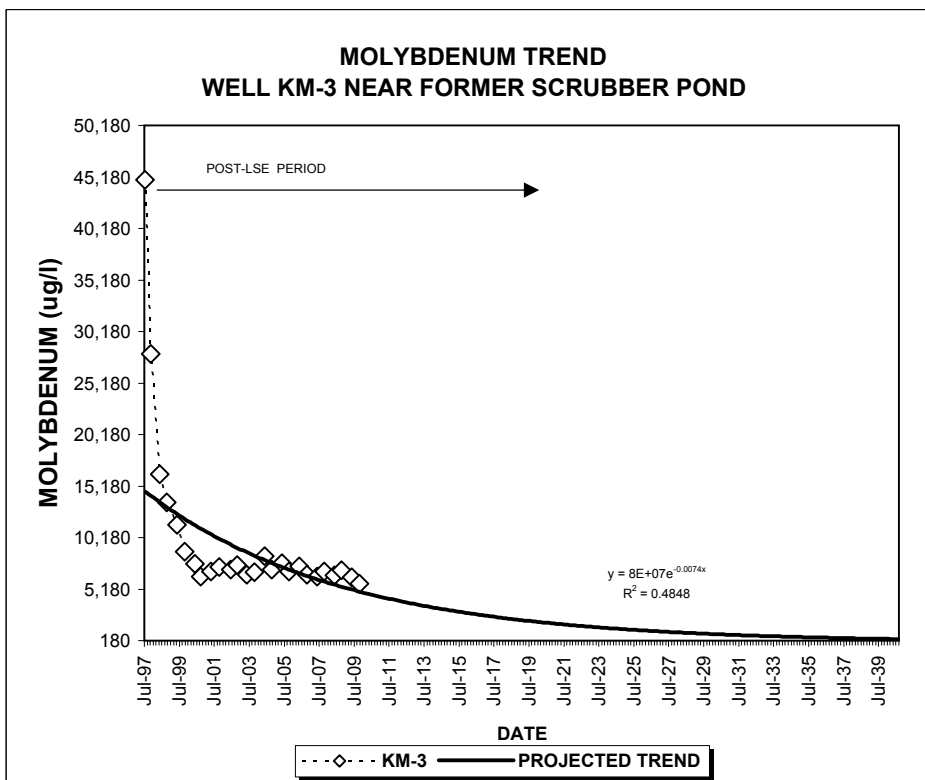
**COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS**

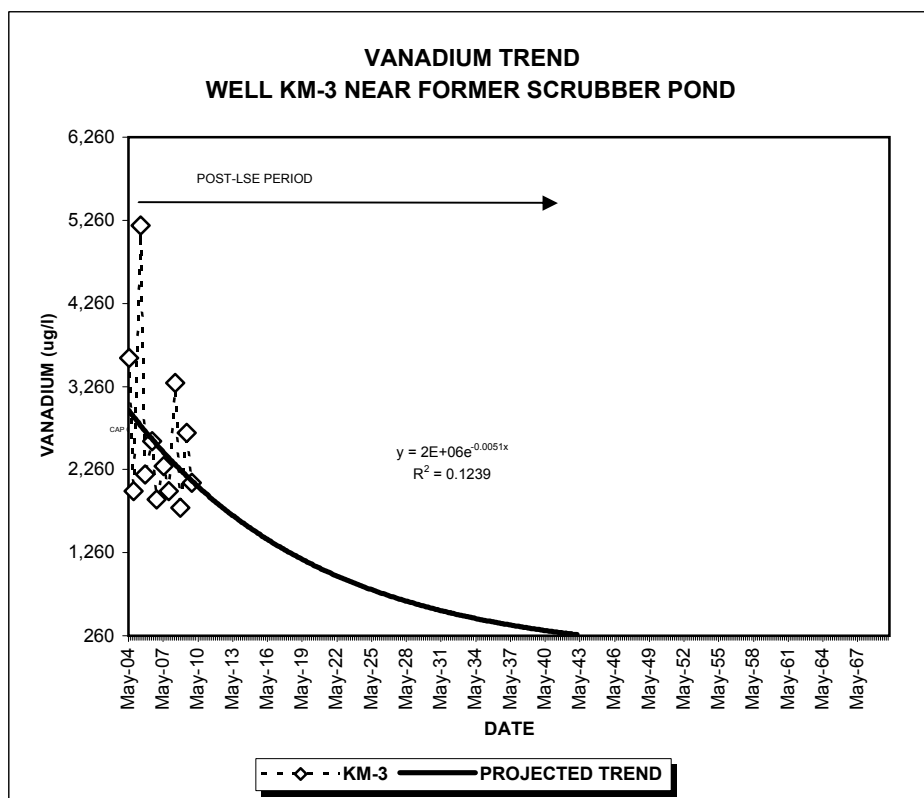
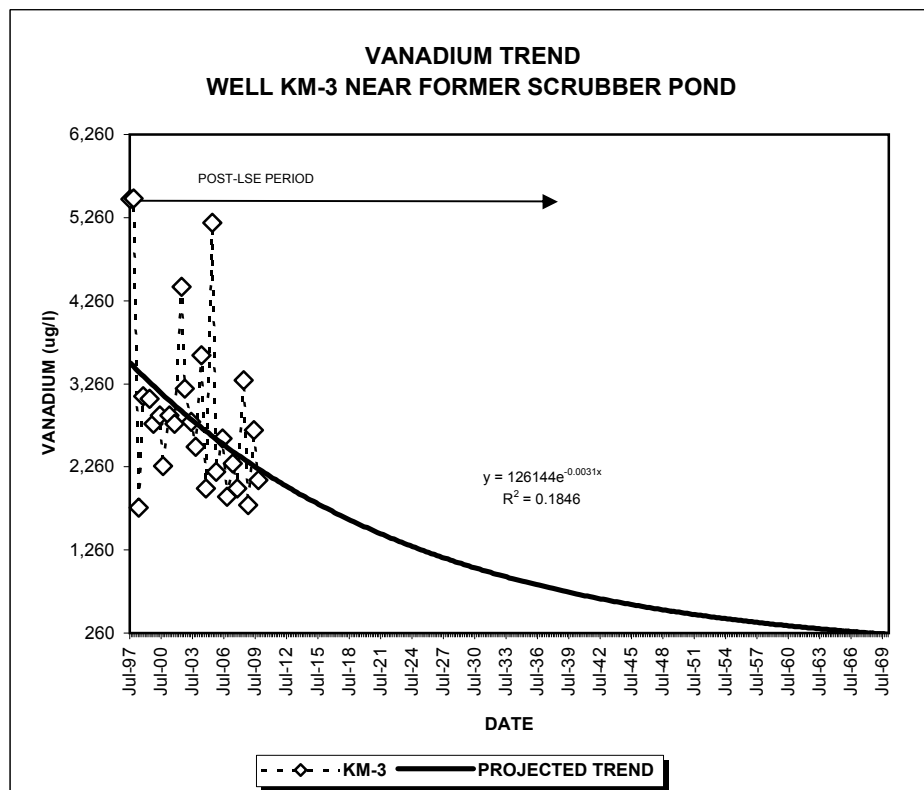




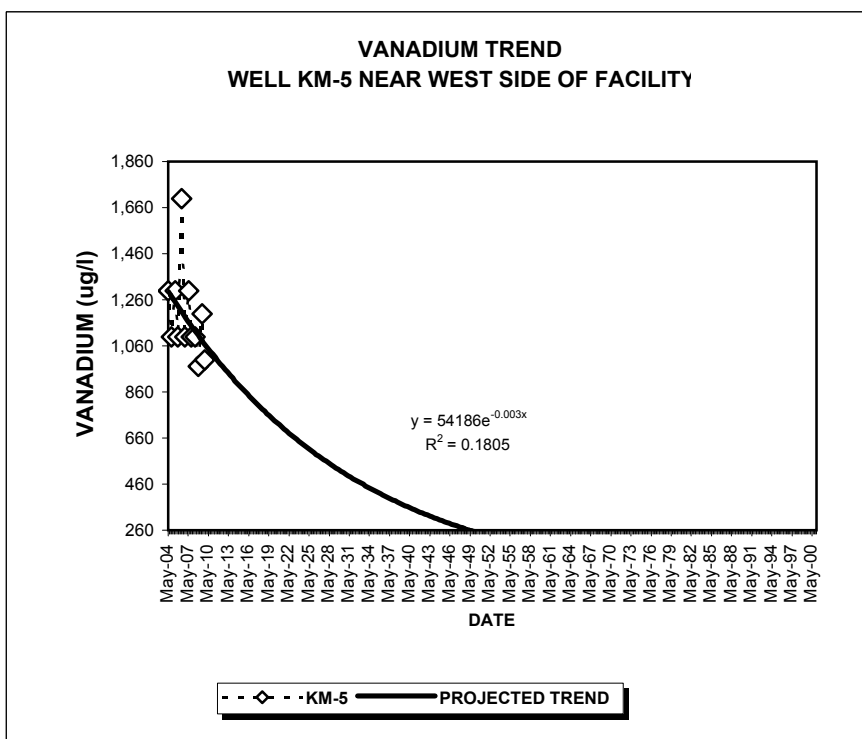
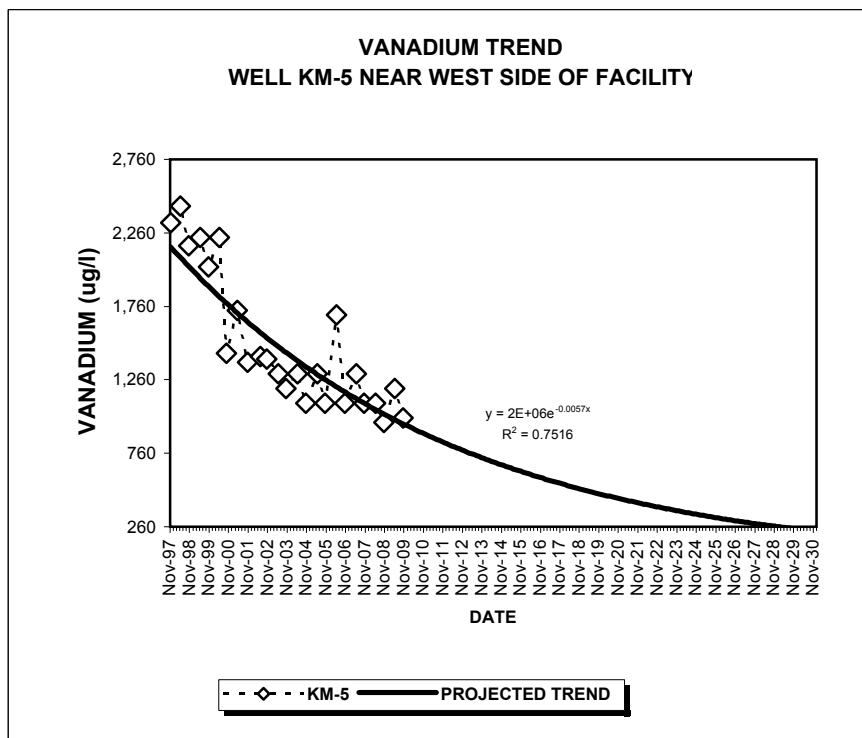


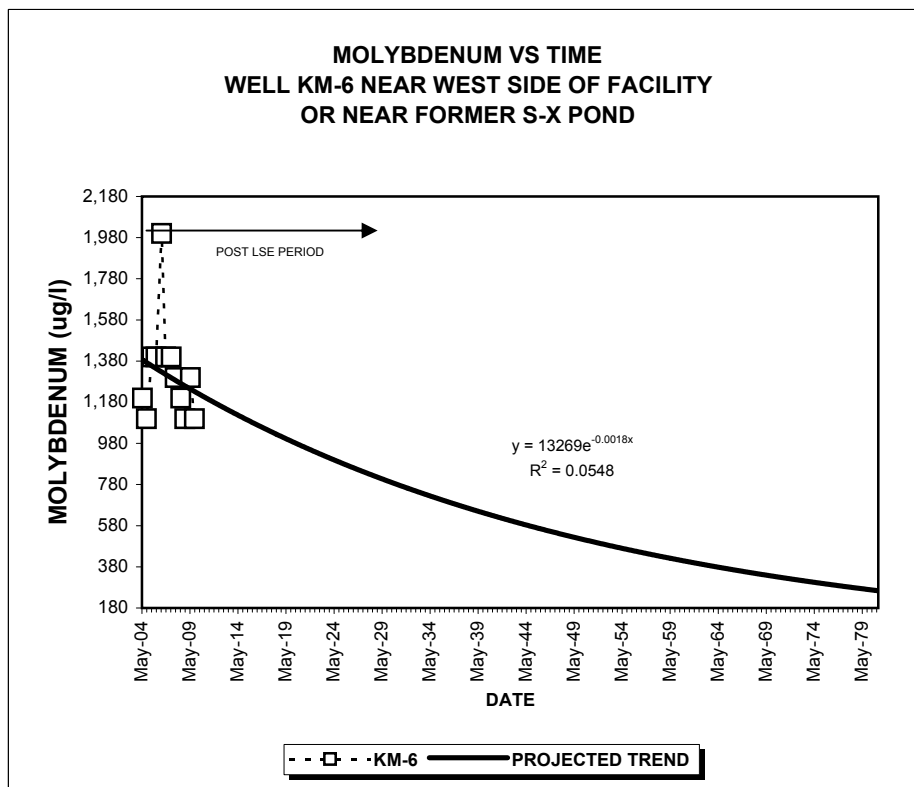
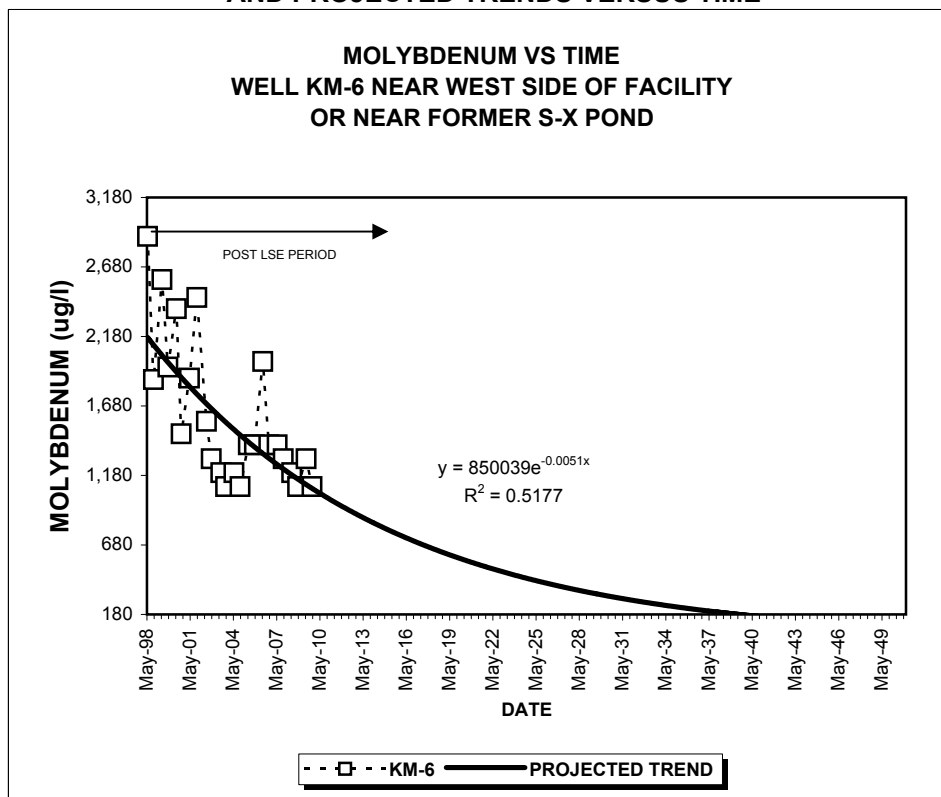




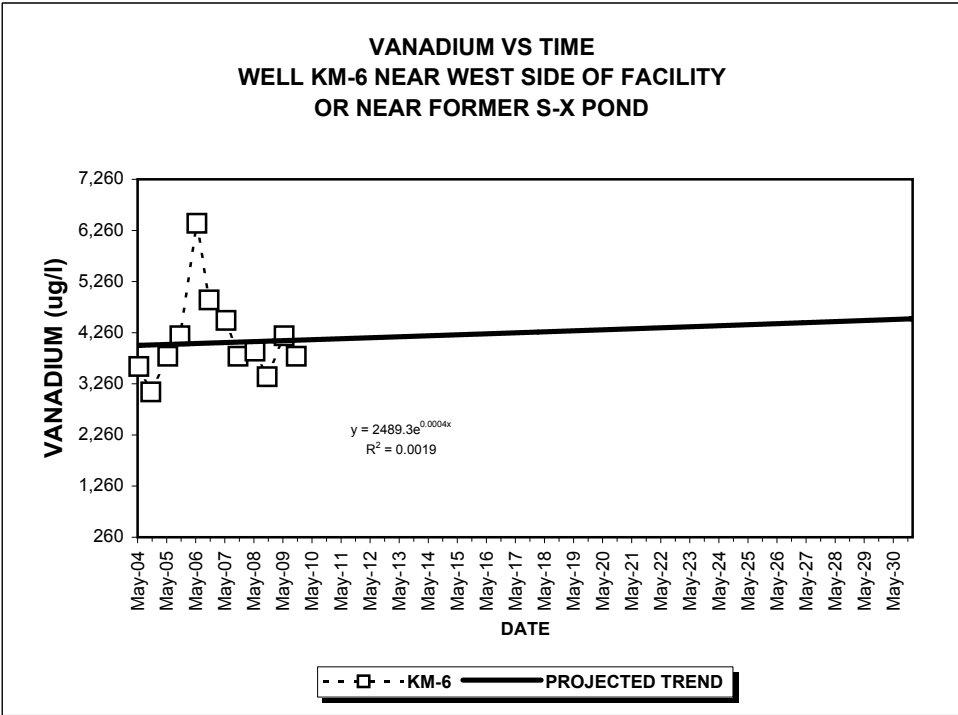
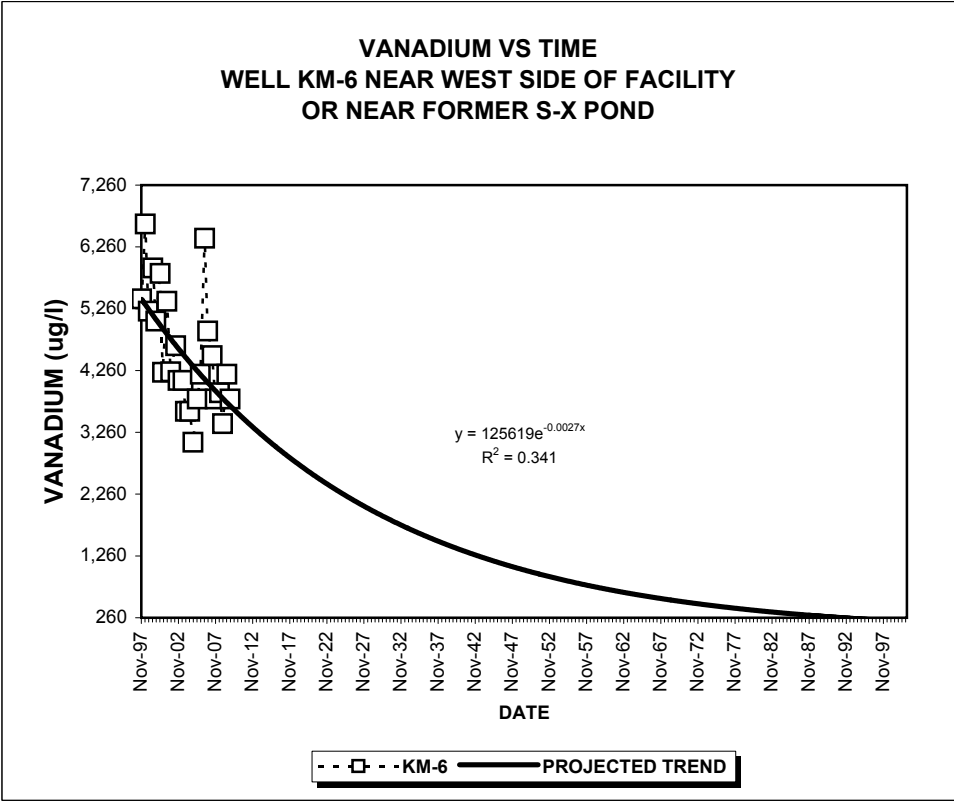


## COC CONCENTRATION TRENDS WITH TIME AND PROJECTED TRENDS

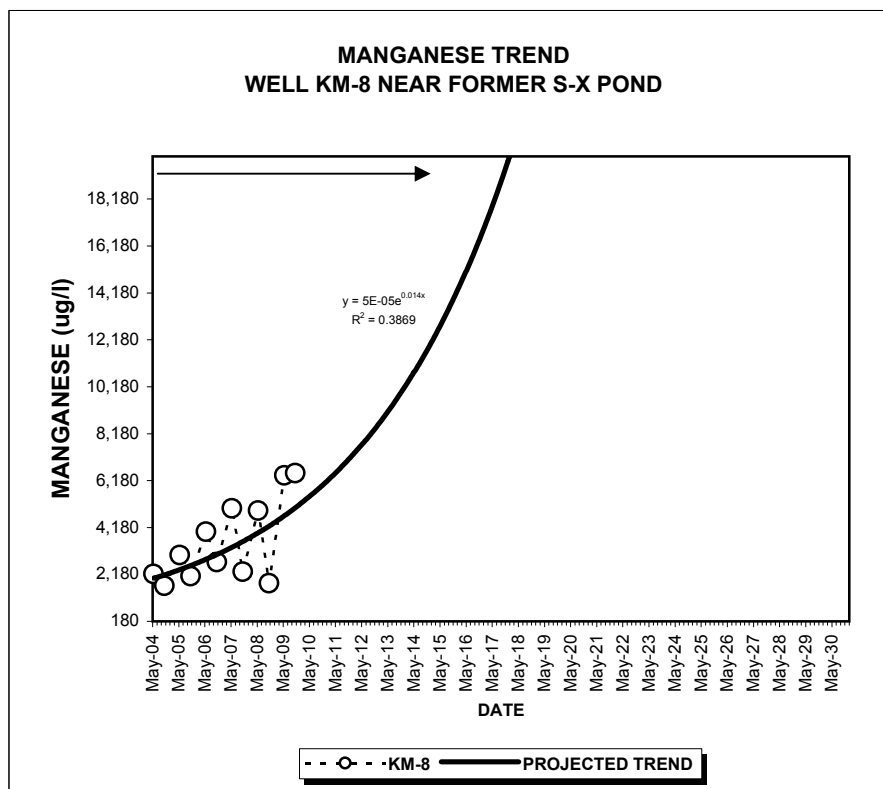
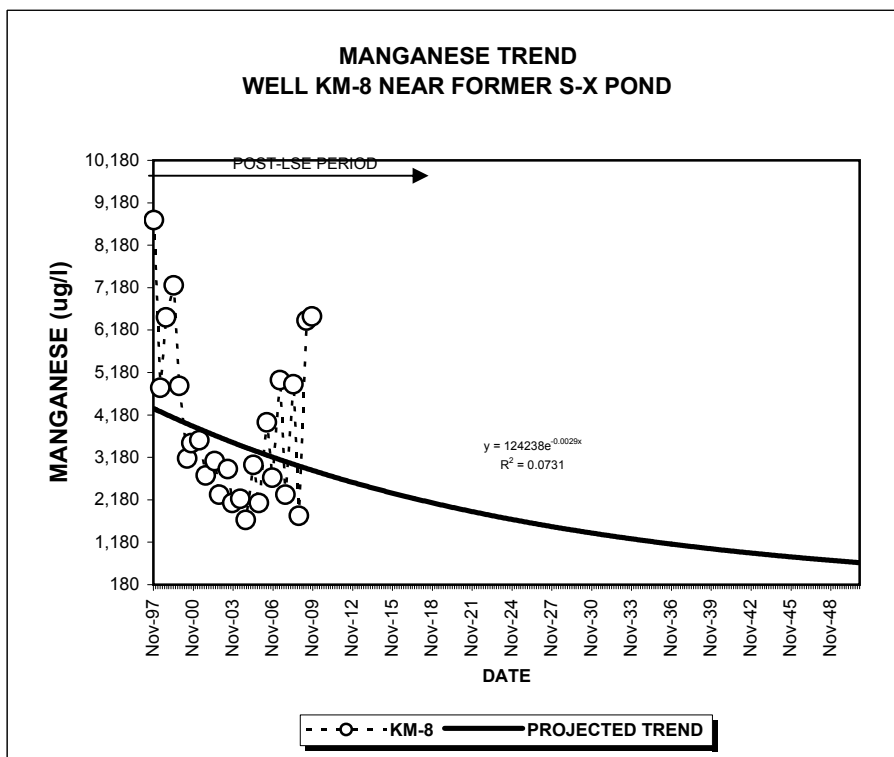


**COC CONCENTRATIONS  
AND PROJECTED TRENDS VERSUS TIME**

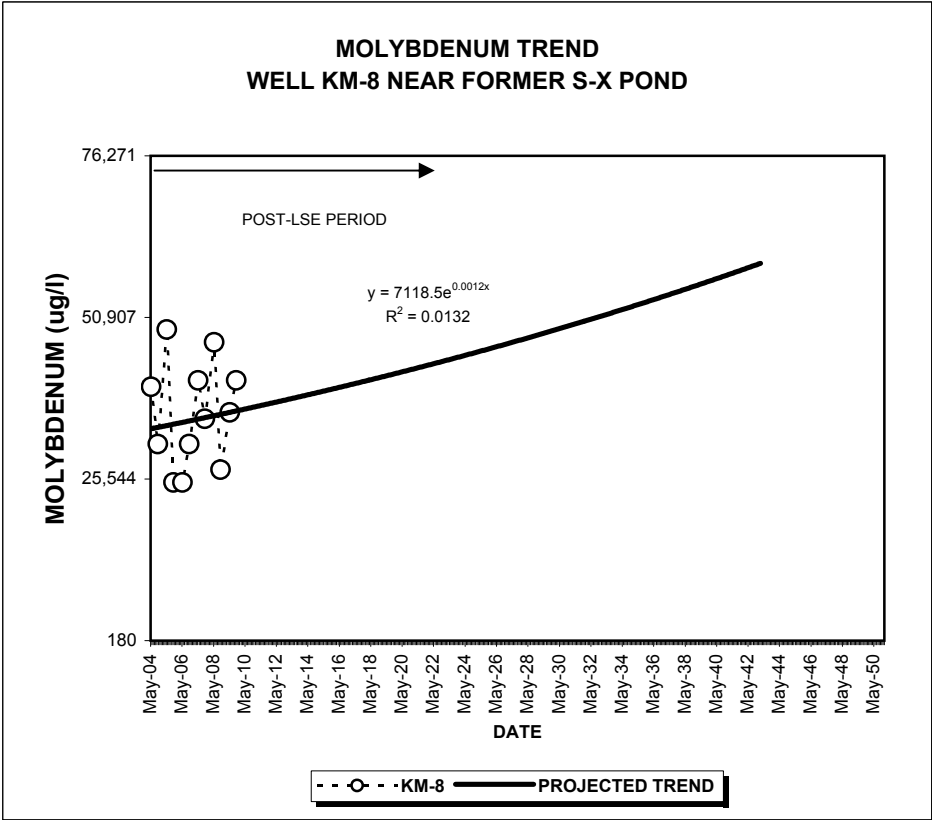
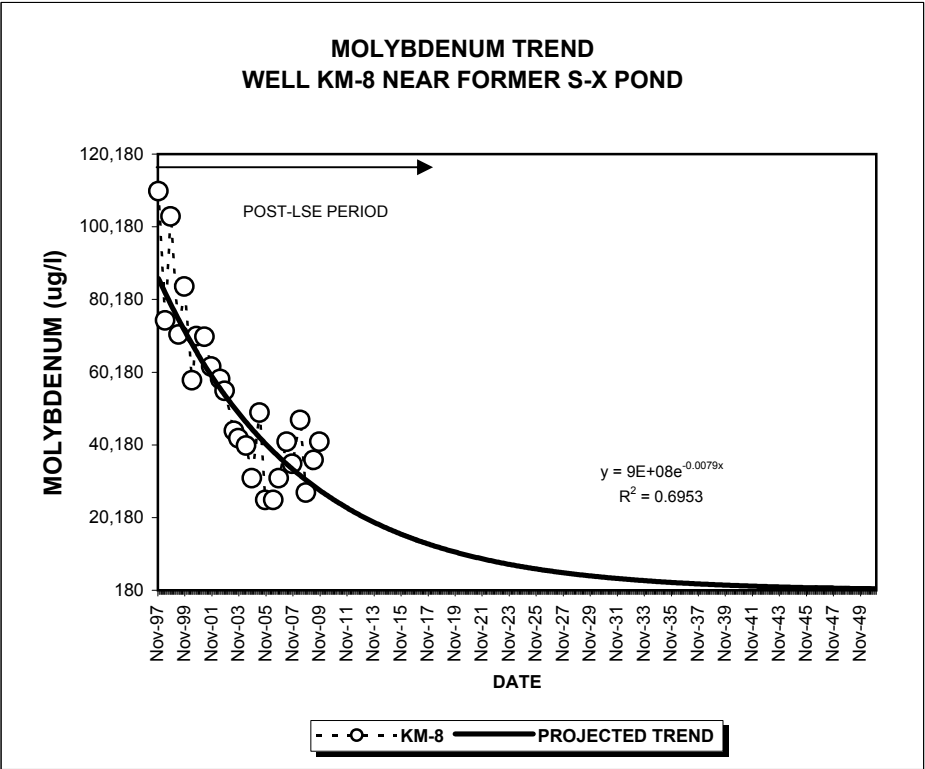
**COC CONCENTRATIONS  
AND PROJECTED TRENDS VERSUS TIME**



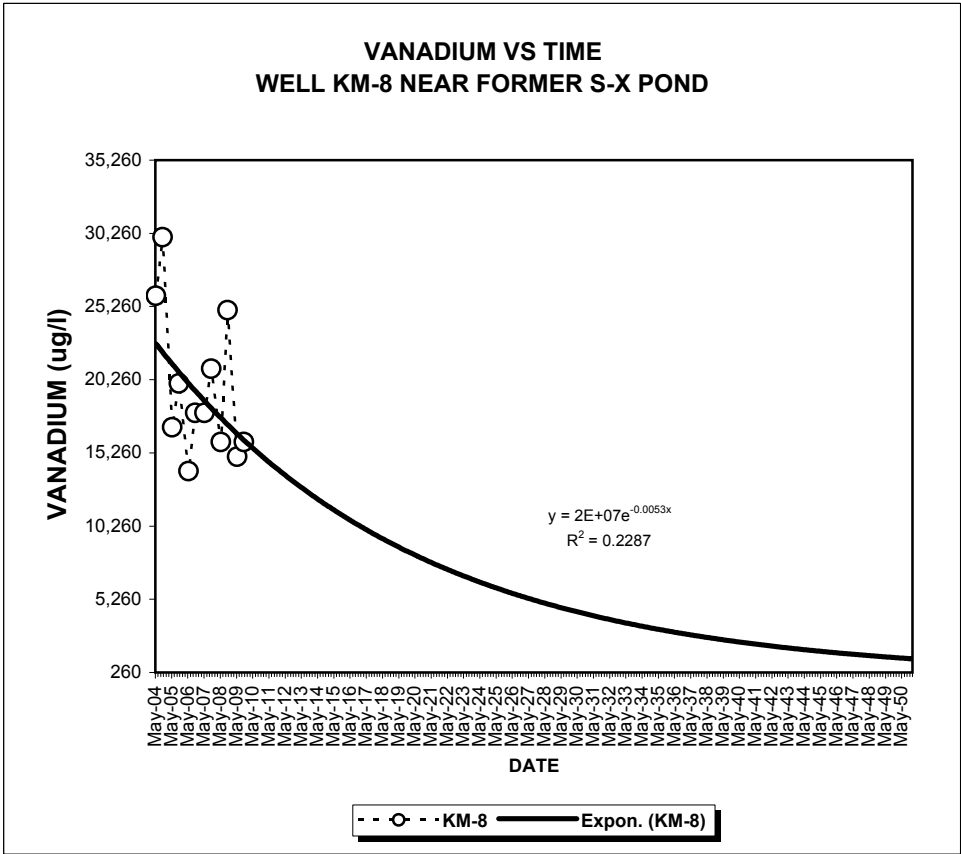
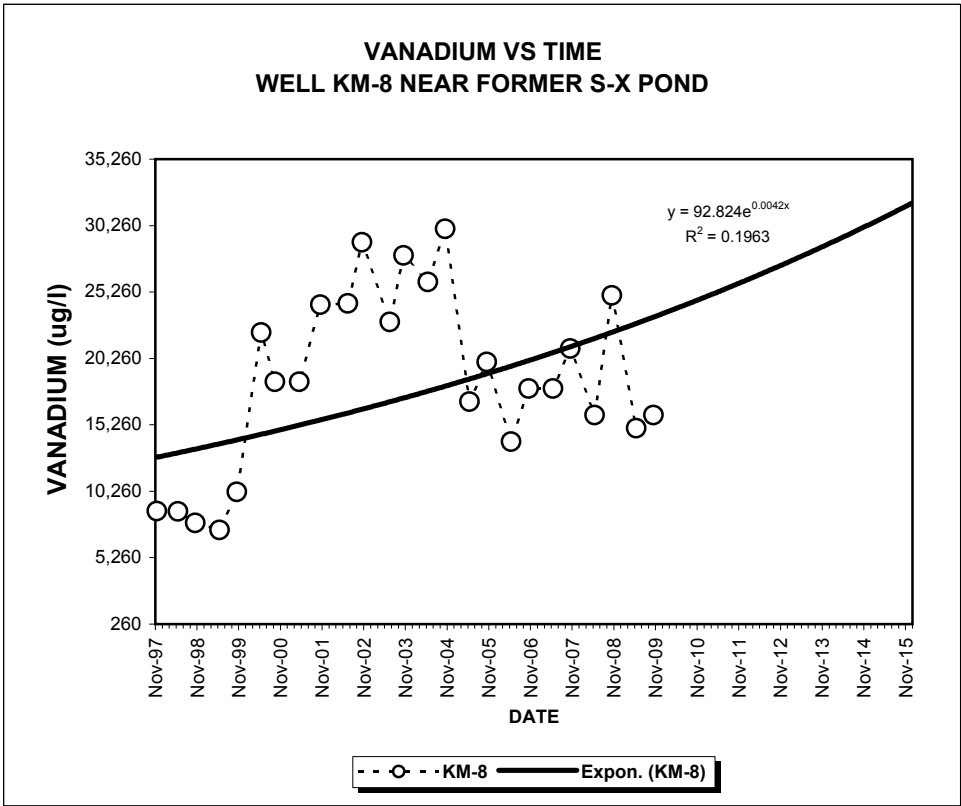


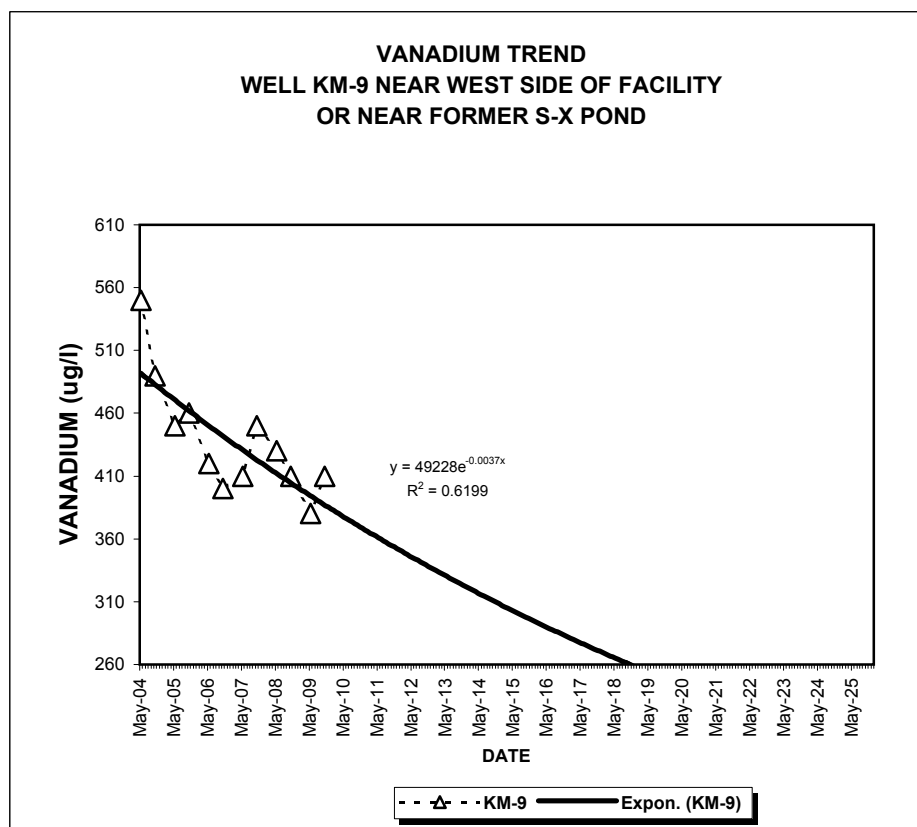
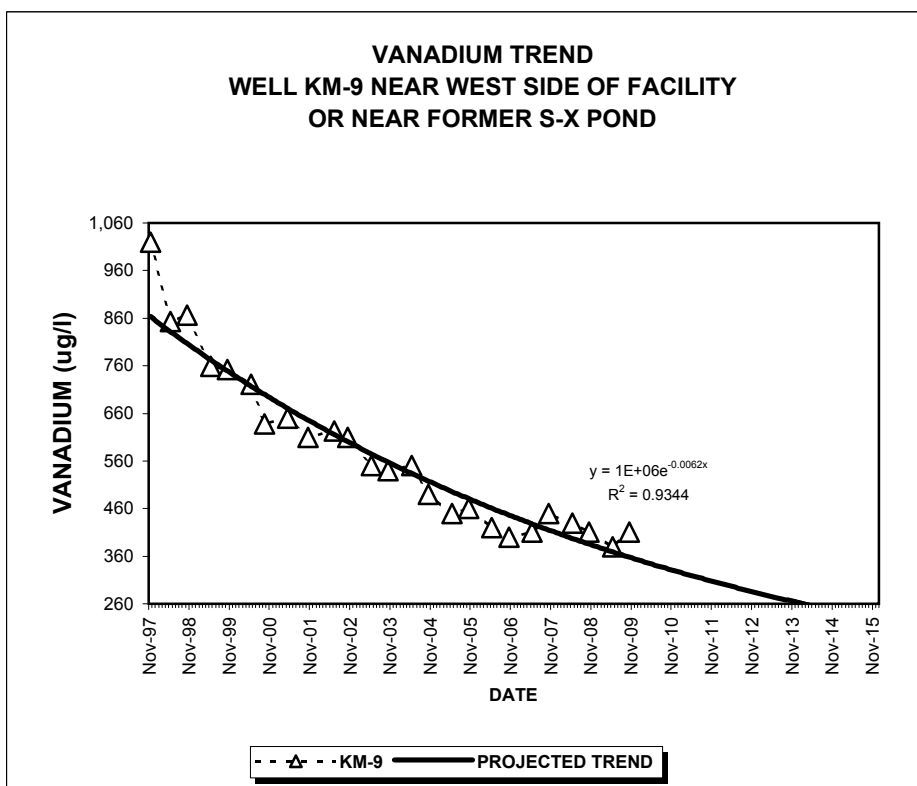
**COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS**

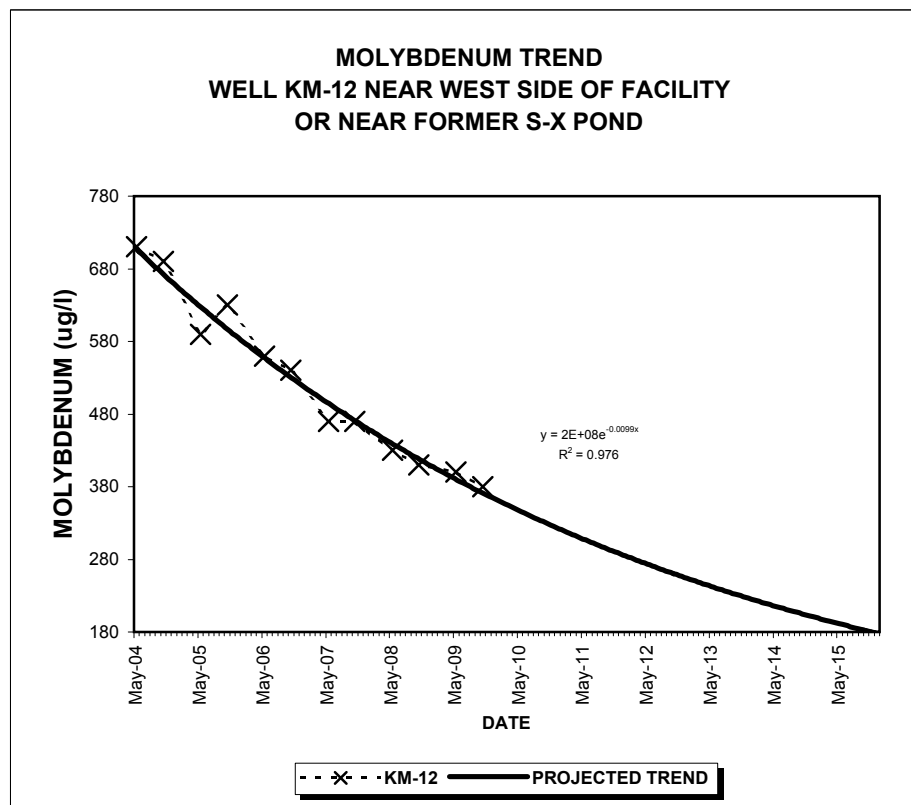
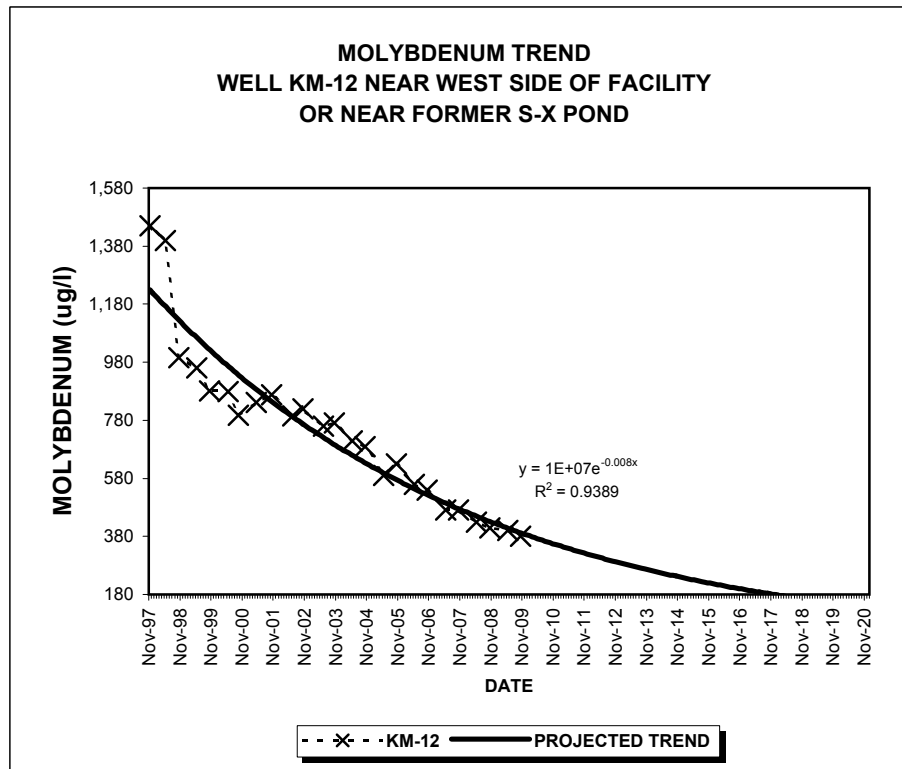
COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS



COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS



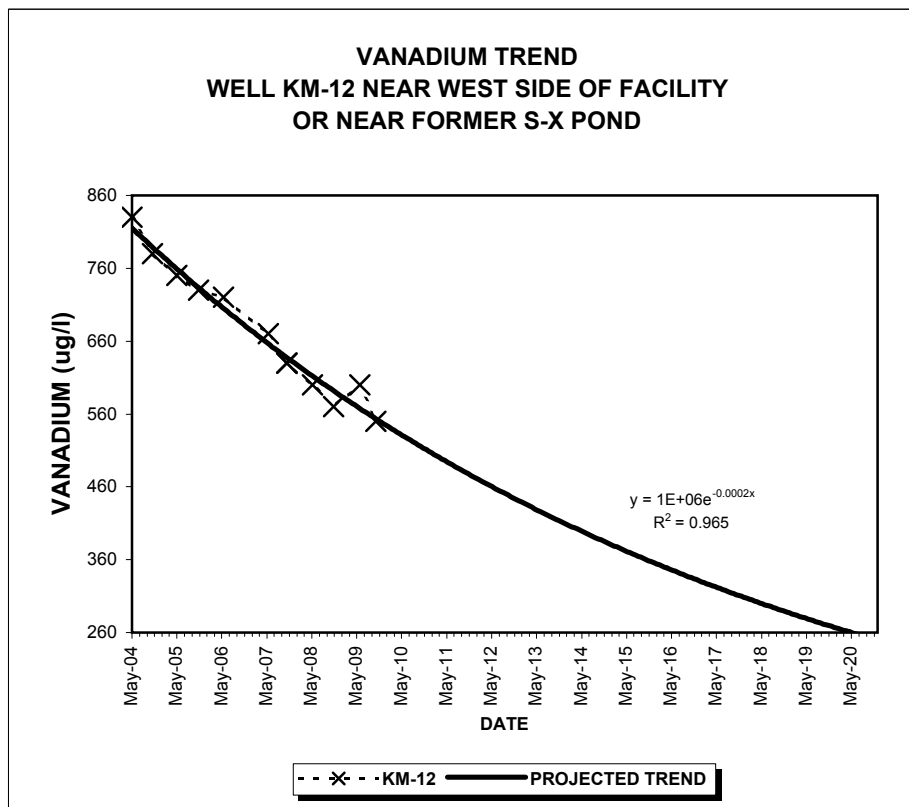
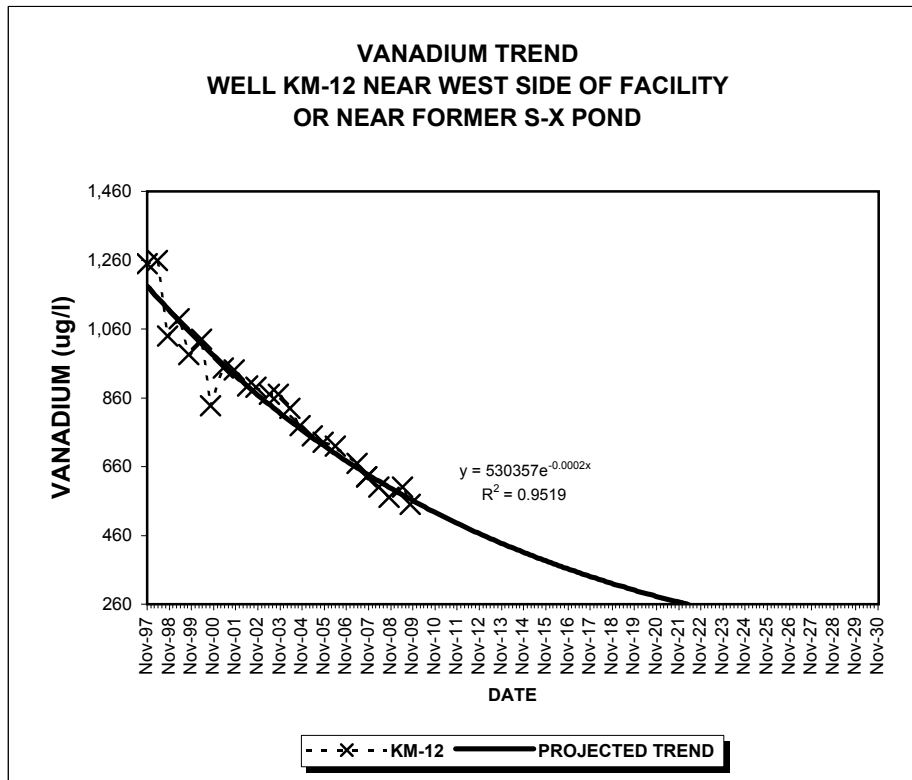
**COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS**

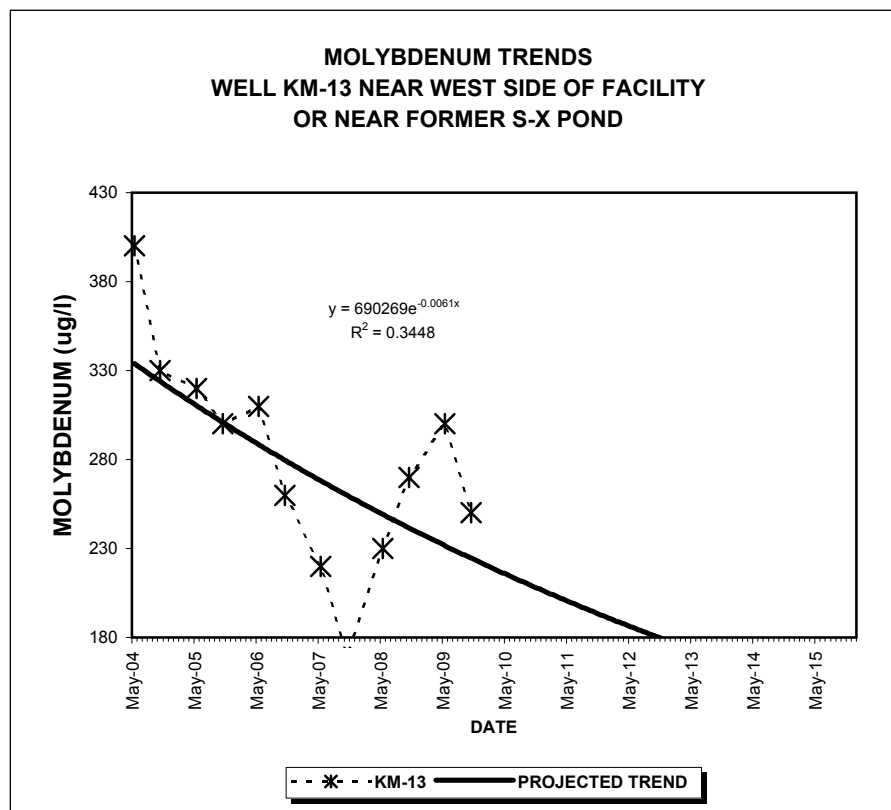
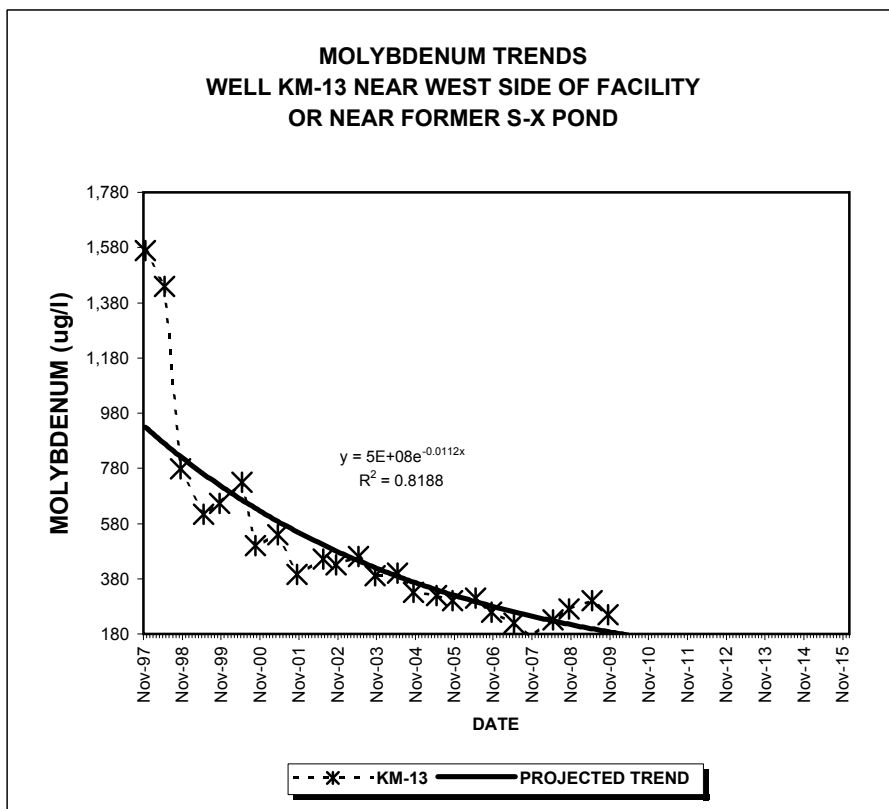
**COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS**

RBC FOR VANADIUM IS 260 UG/L

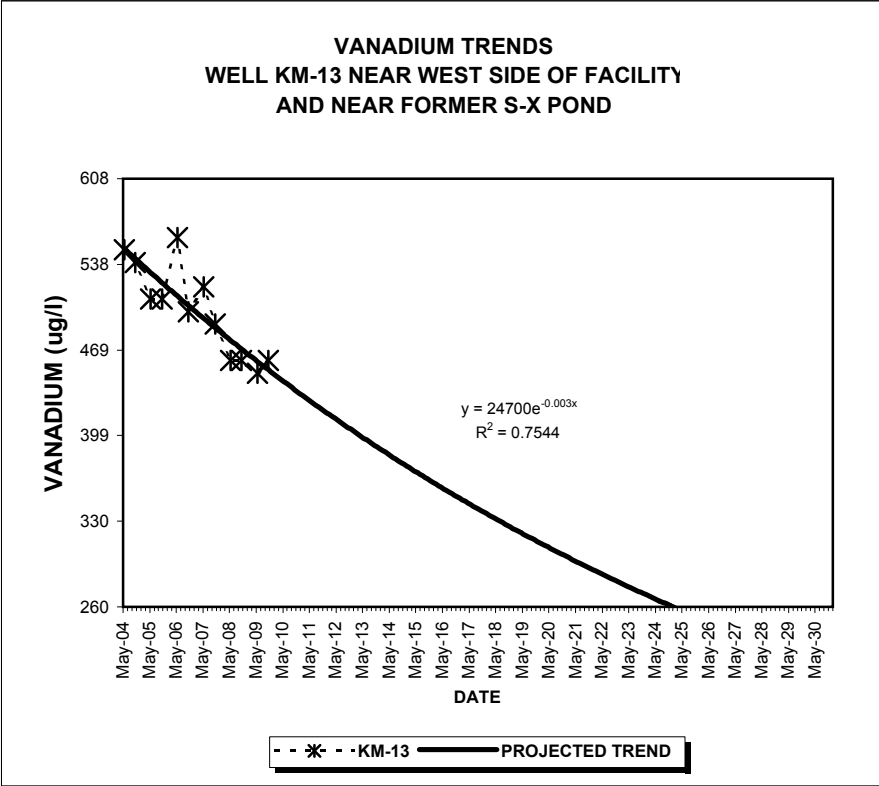
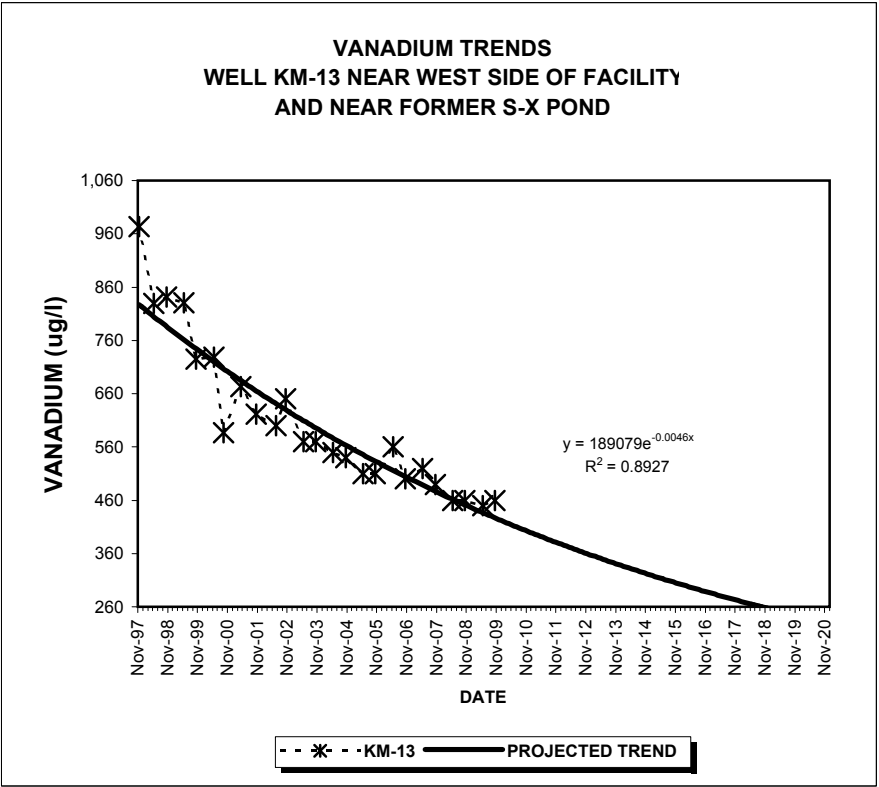
KM-12 IS A POC WELL

PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING REROUTING OF THE S-X STREAM

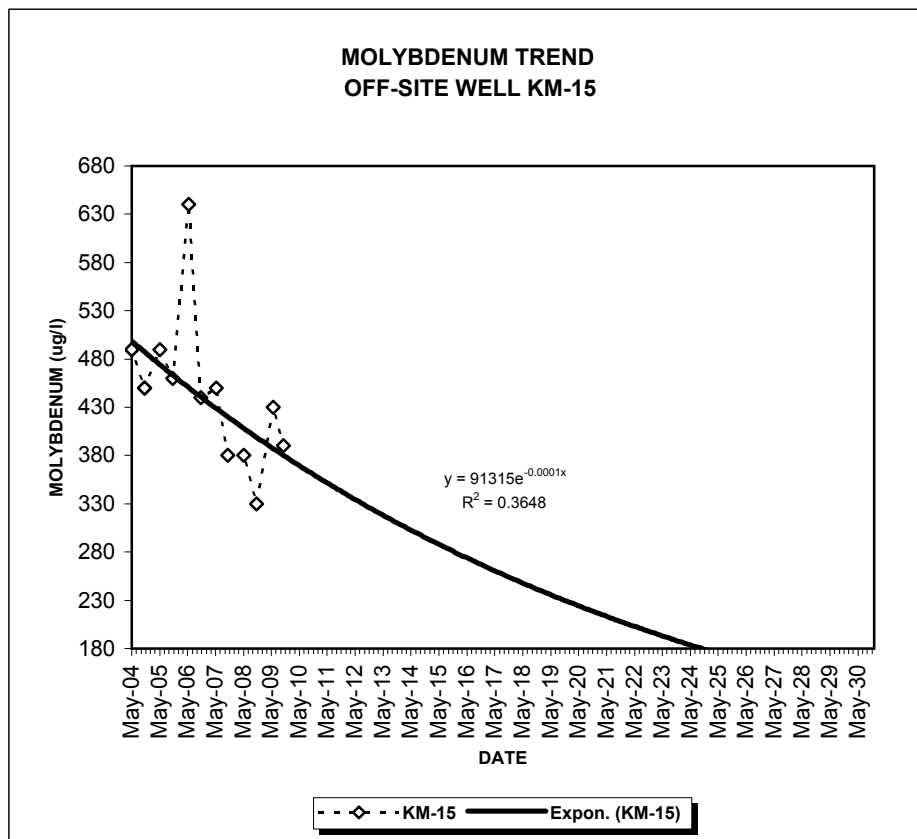
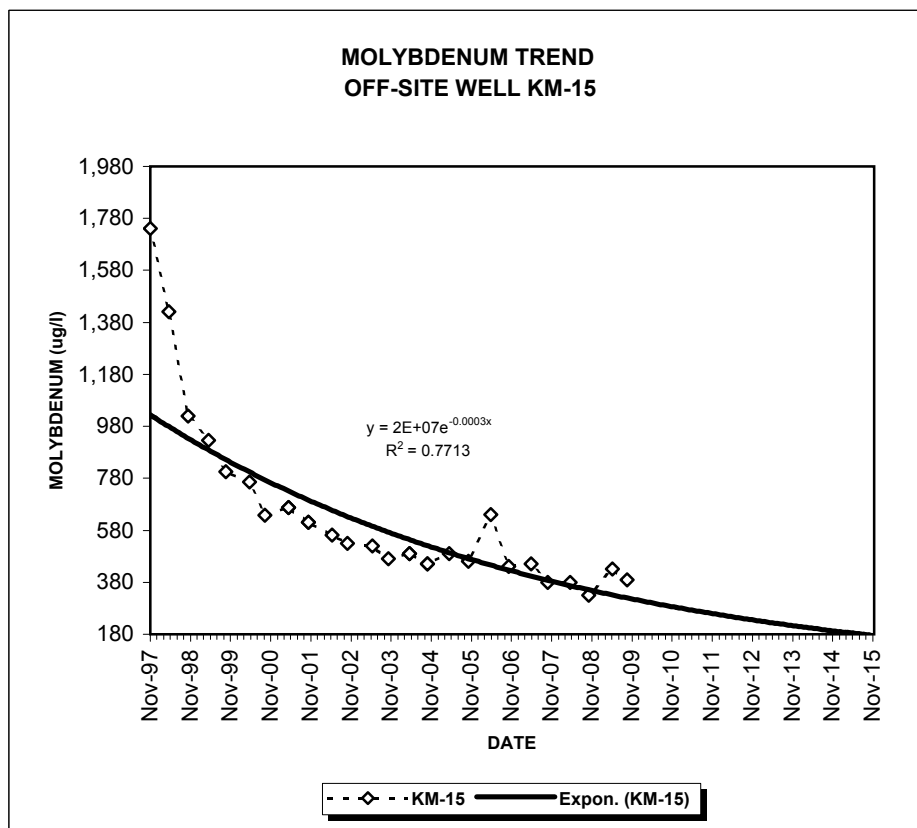
**COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS**

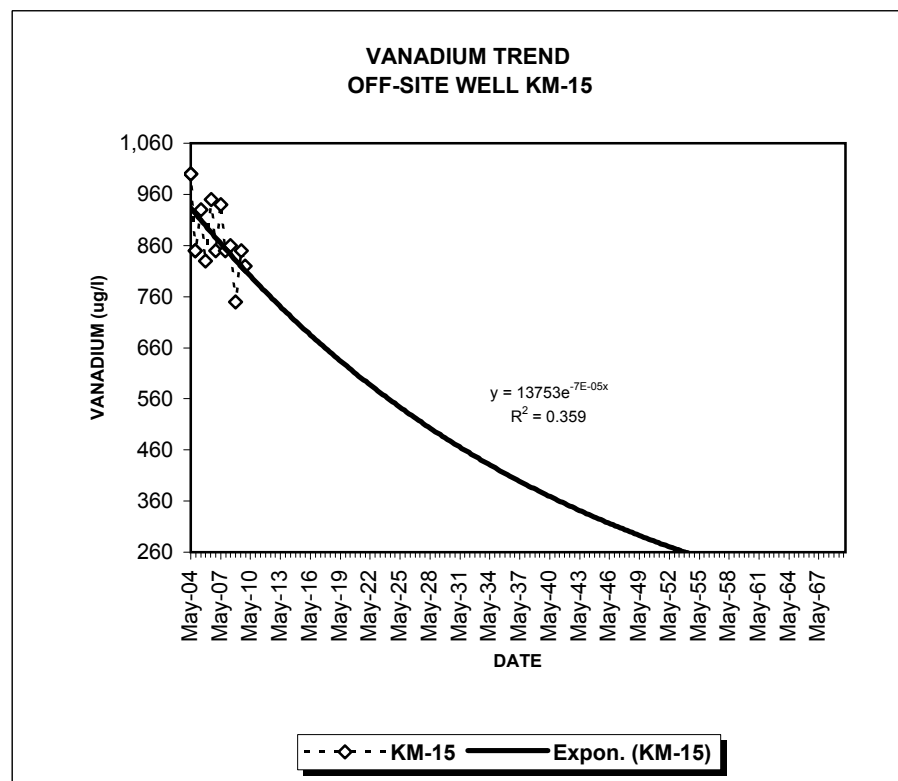
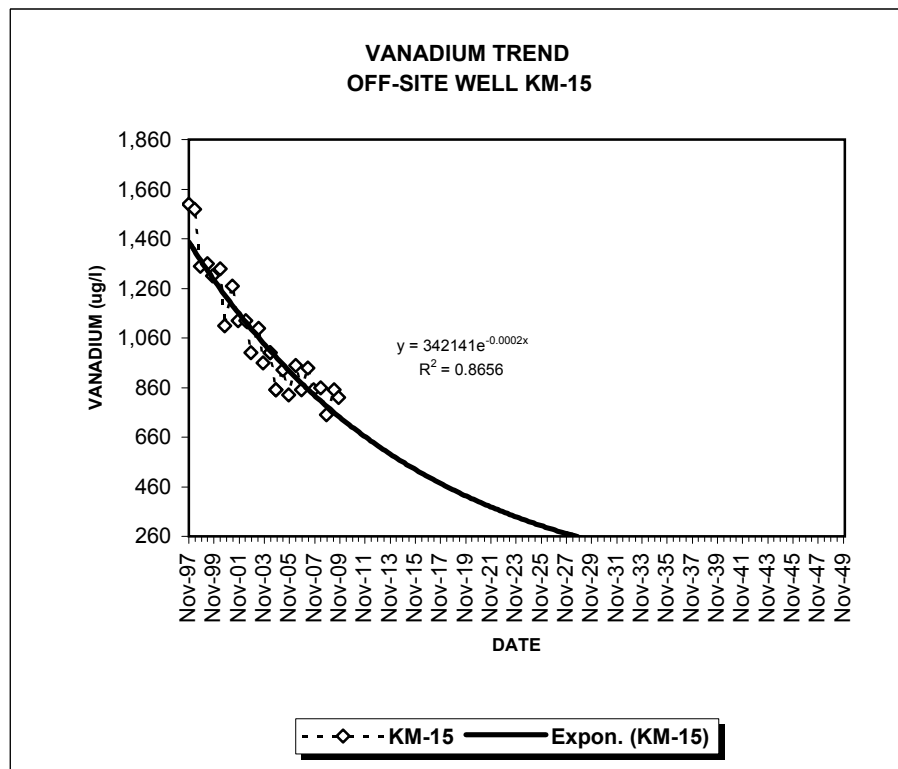
**COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS**

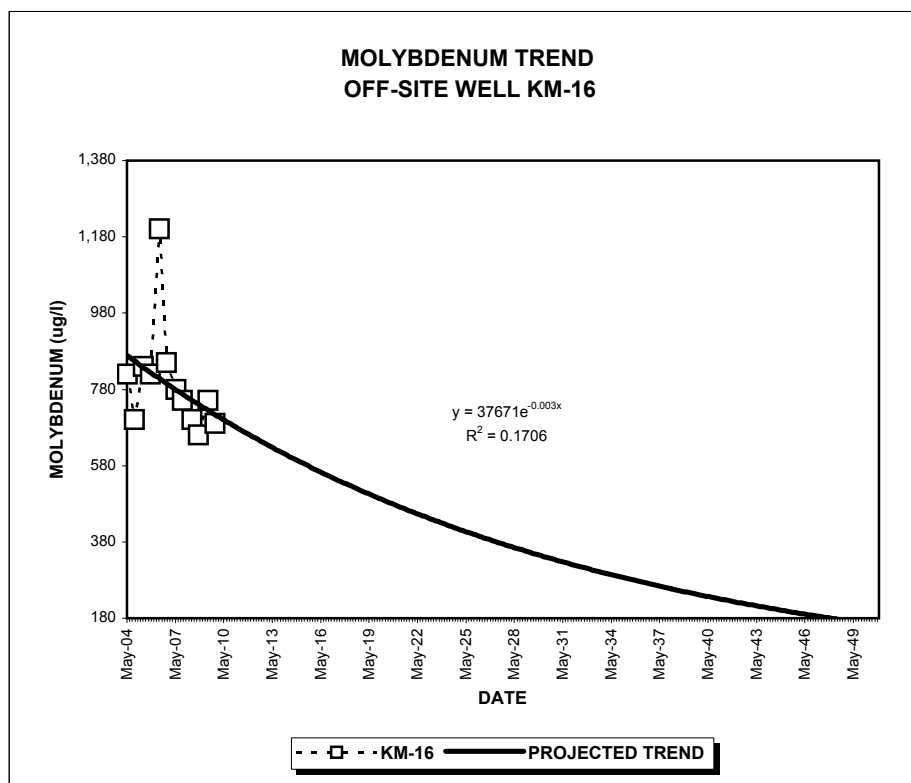
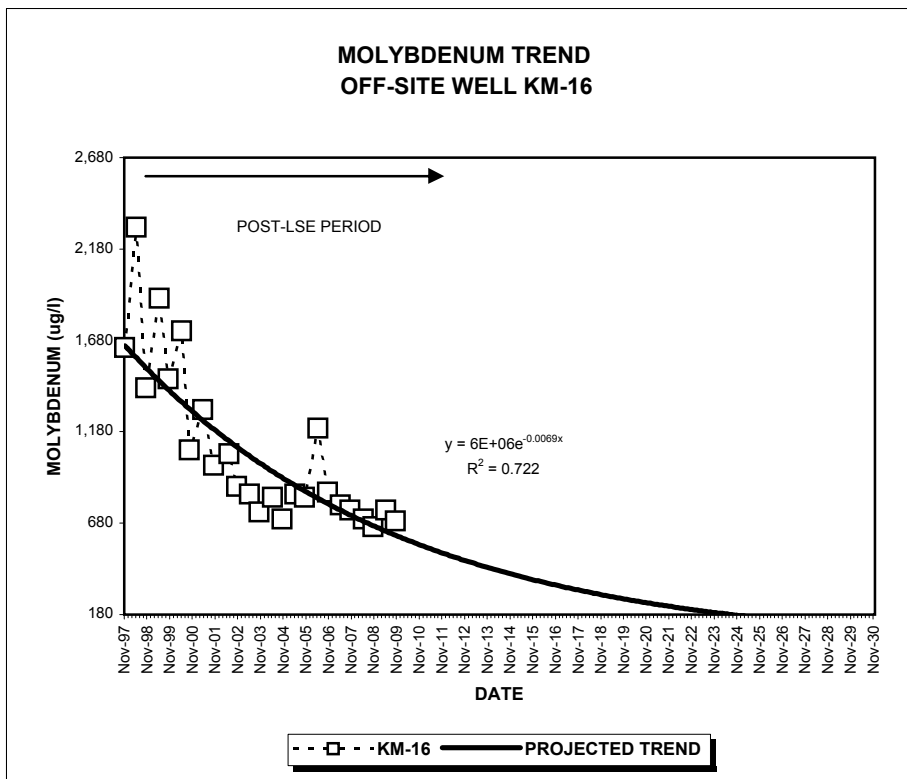
**COC CONCENTRATION TRENDS WITH TIME  
AND PROJECTED TRENDS**

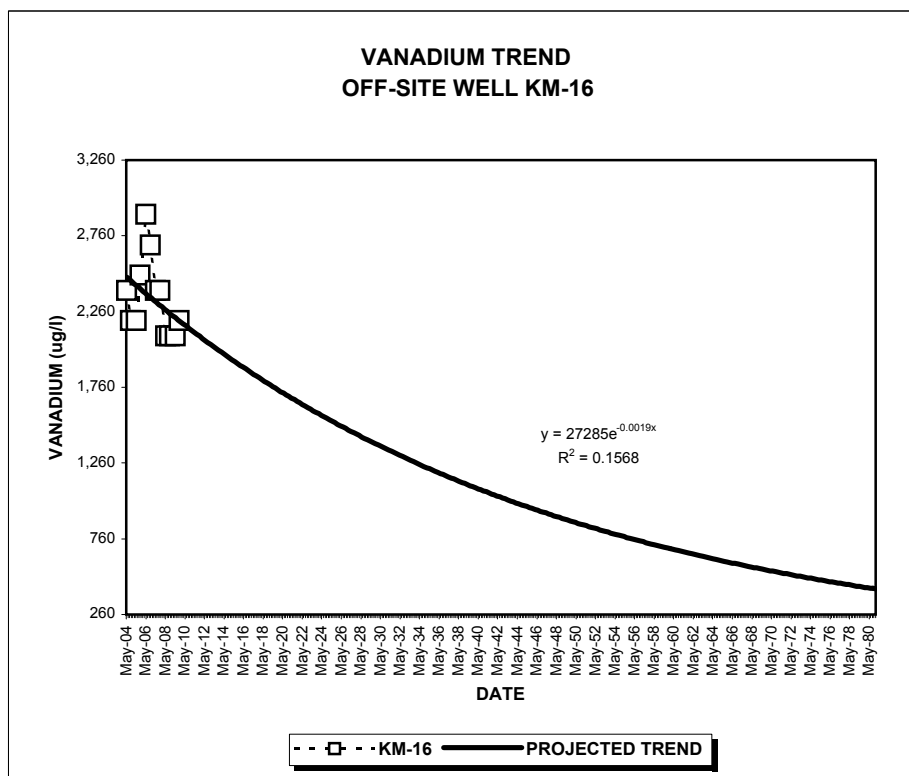
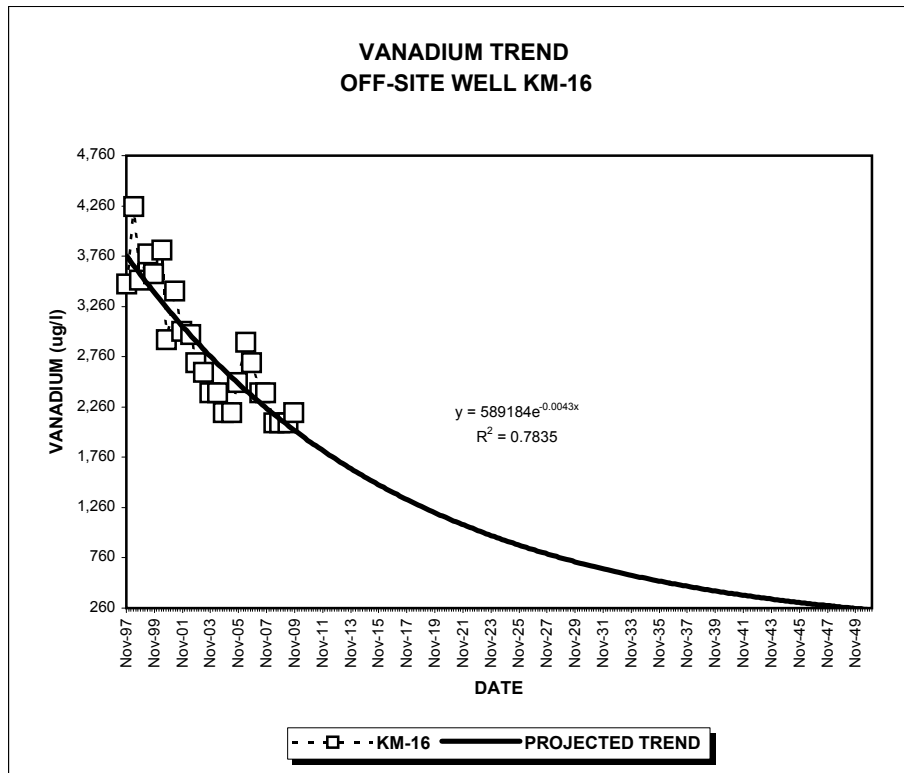


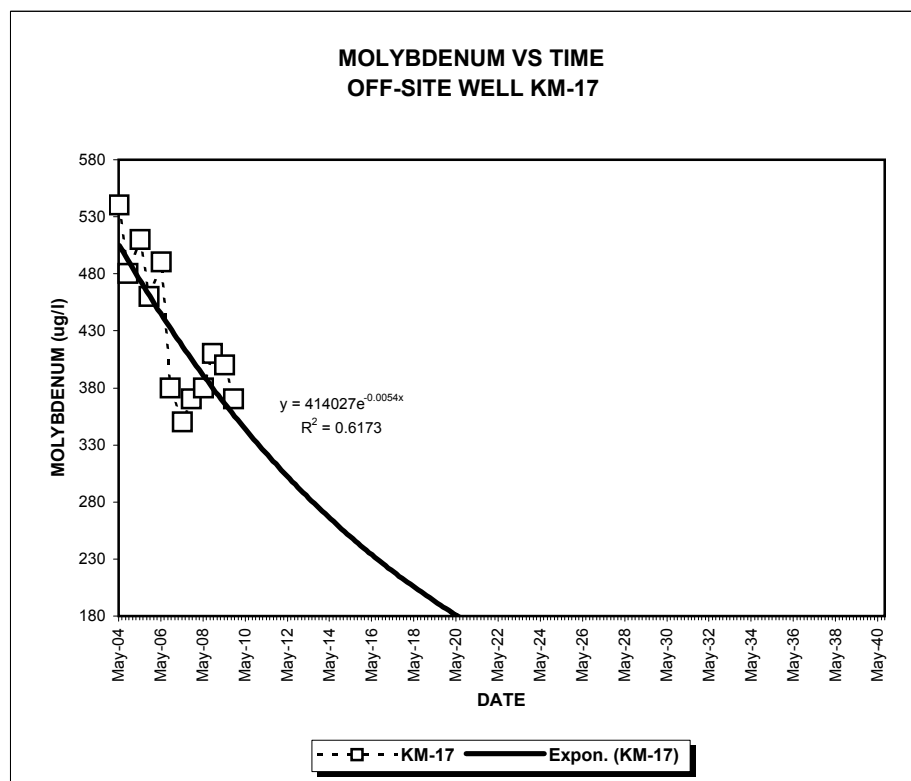
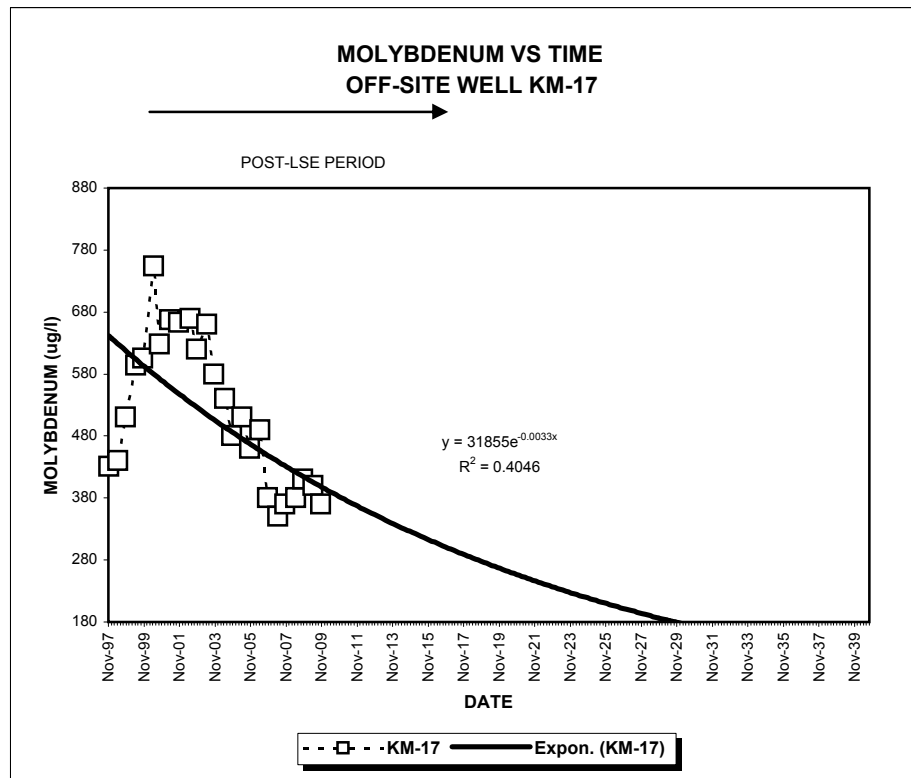


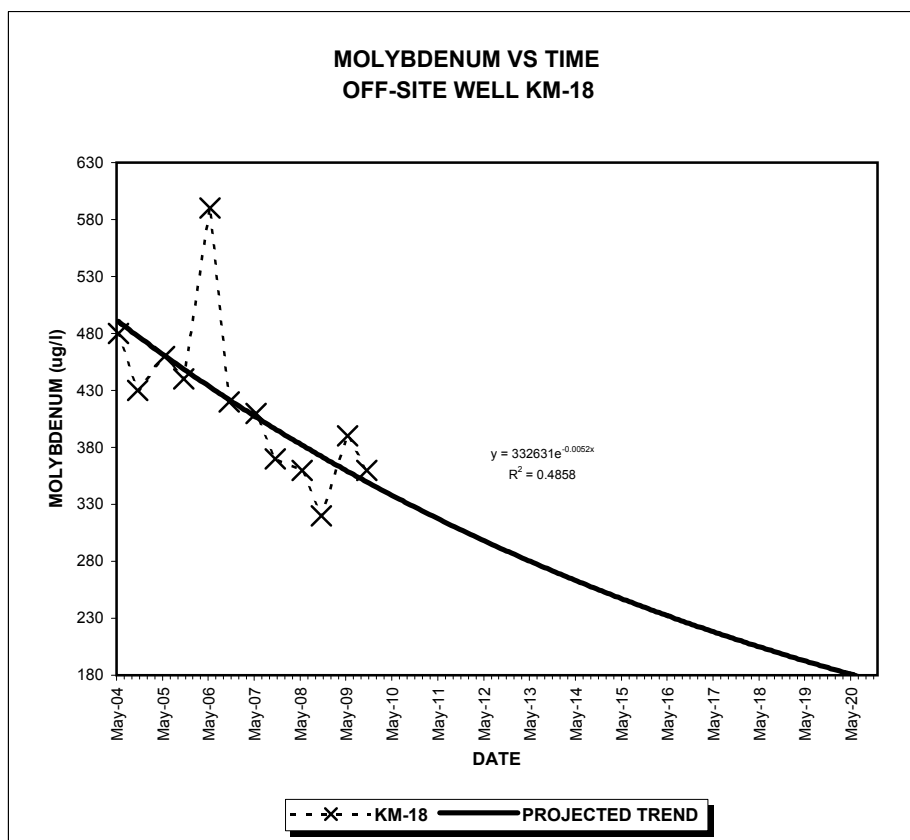
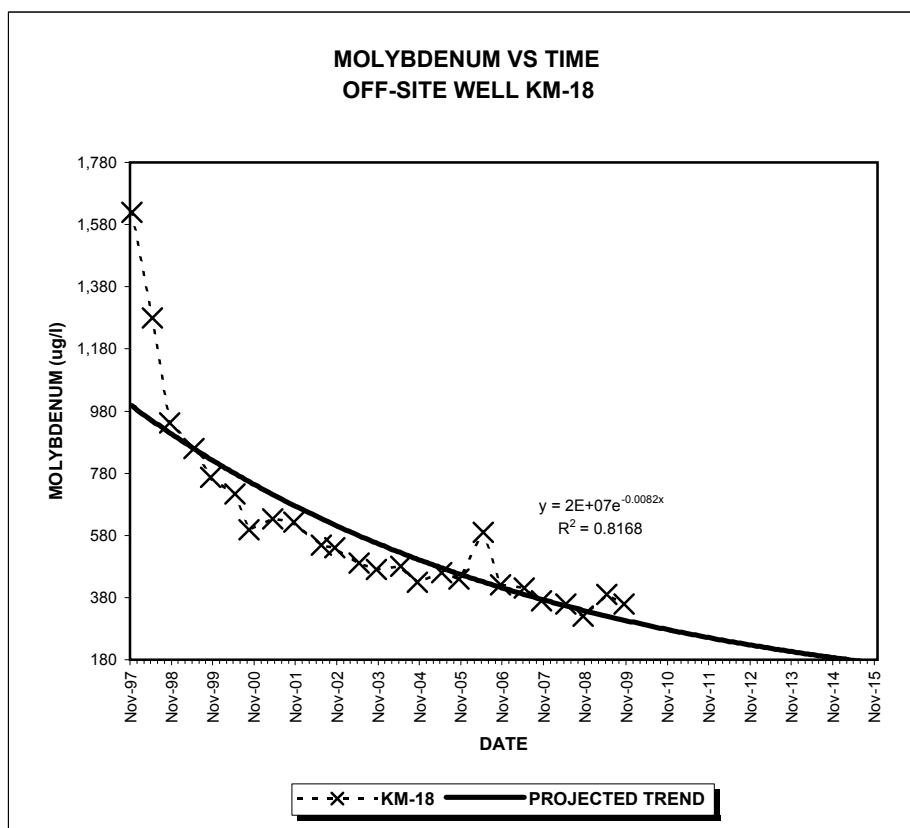
**COC CONCENTRATIONS WITH TIME  
AND PROJECTED TRENDS**

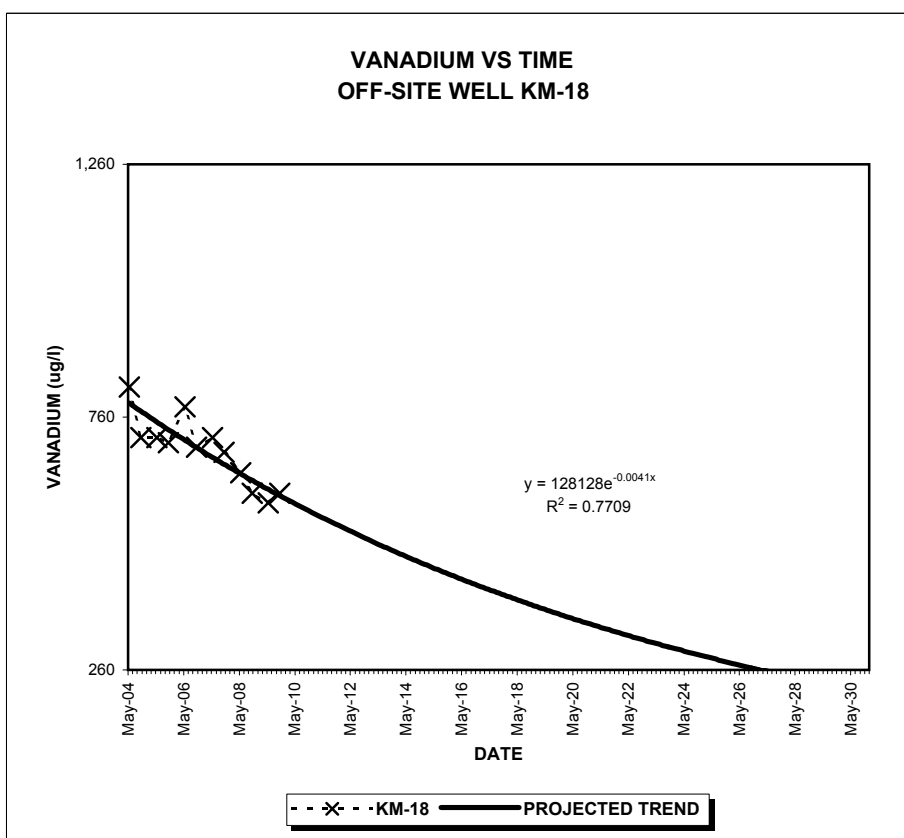
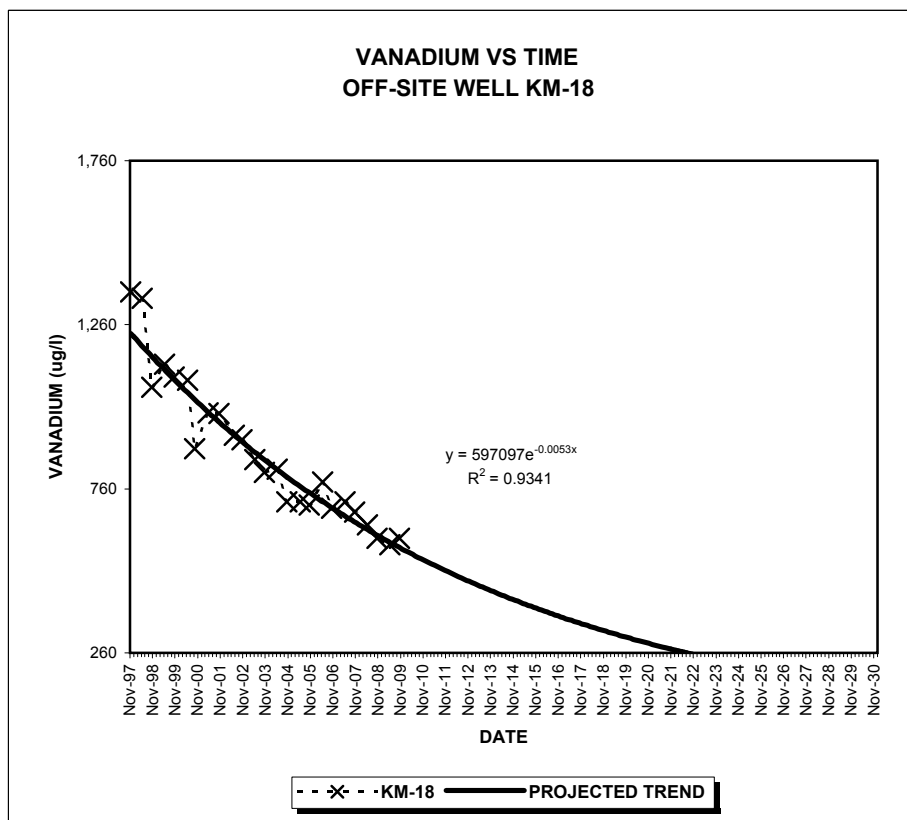
**COC CONCENTRATIONS WITH TIME  
AND PROJECTED TRENDS**

**COC CONCENTRATIONS WITH TIME  
AND PROJECTED TRENDS**

**COC CONCENTRATIONS WITH TIME  
AND PROJECTED TRENDS**

**COC CONCENTRATIONS WITH TIME  
AND PROJECTED TRENDS**

**COC CONCENTRATIONS WITH TIME  
AND PROJECTED TRENDS**

**COC CONCENTRATIONS WITH TIME  
AND PROJECTED TRENDS**

**APPENDIX C**  
**2009 EVERGREEN MONITOR WELL SAMPLING**



## **Sprague Environmental LLC**

**P.O. Box 284  
Soda Springs, Idaho 83276  
(208) 547-3210  
(208) 547-0259 FAX**

August 26, 2009

Mr. Alan Skinner  
City of Soda Springs  
9 West 2<sup>nd</sup> South  
Soda Springs, ID 83276

Re: Evergreen Monitor Well Sampling

Dear Alan:

The four monitor wells located on the Evergreen facility were sampled on June 2, 2009. The results of the analysis are presented in this letter.

### Sampling

Each monitor wells was sampled using a clean Teflon bailer. The depth to ground water was measured and at least three casing volumes of water were removed prior to collecting the samples. When the sample bottles were filled the temperature, pH and conductivity of the ground water was measured in the field. This information was recorded on a field sampling form for each well. The samples that were analyzed for dissolved constituents were filtered in the field using a disposable 0.45 micron filter. Copies of the field sampling forms are attached. The sample bottles were sent to ACZ Laboratories in Steamboat Springs, Colorado under chain of custody for analysis.

### Laboratory Analysis

The analytical results for each sample are attached. The analysis was completed using the analyte list approved by the Idaho Department of Environmental Quality prior to the sampling event in 2008.

There were a few analytical qualifications noted in the report. These analytical qualifiers are discussed below.

## **EV-1**

There were no certification qualifiers for the EV-1 samples. However, the cooler containing the EV-1 samples arrived at the lab with a temperature of 7.5 °C. The acceptable maximum temperature is 4 °C. The samples were properly preserved so the elevated temperature will not affect the results.

Nitrate/Nitrite: Relative Percent Difference (RPD) was not used for data validation because the sample concentration was too low for accurate evaluation (<10XMDL). Relative Percent Difference (RPD) was not used for data validation because the sample concentration was too low for accurate evaluation (<10XMDL).

Turbidity: Analysis is performed past holding time. Method holding time is less than or equal to 7 days and sample was received with less than half of the holding time remaining.

## **EV-2**

There were no certification qualifiers for the EV-2 samples. However, the cooler containing the EV-1 samples arrived at the lab with a temperature of 7.5 °C. The acceptable maximum temperature is 4 °C. The samples were properly preserved so the elevated temperature will not affect the results.

Turbidity: Analysis is performed past holding time. Method holding time is less than or equal to 7 days and sample was received with less than half of the holding time remaining. Relative Percent Difference (RPD) was not used for data validation because the sample concentration was too low for accurate evaluation (<10XMDL).

## **EV-3**

There were no analytical qualifiers for the EV-3 samples.

Turbidity: Analysis is performed past holding time. Method holding time is less than or equal to 7 days and sample was received with less than half of the holding time remaining. Relative Percent Difference (RPD) was not used for data validation because the sample concentration was too low for accurate evaluation (<10XMDL).

## **EV-4**

There were no analytical qualifiers for the EV-4 samples.

Turbidity: Analysis is performed past holding time. Method holding time is less than or equal to 7 days and sample was received with less than half of the

holding time remaining. Relative Percent Difference (RPD) was not used for data validation because the sample concentration was too low for accurate evaluation (<10XMDL).

This data is usable and meets the data quality requirements of this project.

## Water Quality

The locations of the monitor wells at the Evergreen site are shown in Figure 1. The ground water elevations for each monitor well are also shown. Figure 1 also shows the estimated potentiometric levels across the site.

The analytical results for each well are shown in Tables 1-8. Tables 1-4 compares the analytical results for each well to the Idaho Ground Water Quality Standard and Tables 5-8 compares the analytical results for each well to the Risk-Based Concentrations (RBC) used in the Kerr-McGee Chemical LLC CERCLA investigation. The concentration trends with time are shown in Figures 2-5. Figure 2 presents the total manganese trend, Figure 3 presents the total molybdenum trend, the total vanadium trend is shown in Figure 4 and the nitrate/nitrite concentration trend is shown in Figure 5. The water quality found in each monitor well is discussed below.

### **EV-1**

The water quality of the water from this well for all of the sampling events is shown in Table 1 and compares the measured concentrations to the ground water quality standard. The nitrate+nitrite concentration has decreased over time and is currently slightly less than the primary ground water standard of 10 mg/l. A possible source of nitrate+nitrite observed in this well is the agricultural field located to the north of the well, but this has not been confirmed. This well is not in an area within the former plant where the water could have been impacted by the operation because it is off-gradient from the processing area as shown by the potentiometric map (Figure 1). The total and dissolved arsenic concentrations are smaller than the primary drinking water standard of 0.05 mg/l. The water quality of this sample exceeds the secondary ground water quality standard for TDS. The total and dissolved aluminum concentration was less than the secondary ground water quality standard. Both the total and dissolved manganese concentrations were smaller than the secondary standard.

Table 5 compares the measured metals concentrations from the sampling events to the RBC for each metal. The constituents exceeding the RBC at EV-1 in the June 2009 sample are total and dissolved molybdenum and total and dissolved vanadium.

The total manganese concentration trend is shown on Figure 2. This trend continues to show decreasing concentrations over time. The total manganese concentration is smaller than the secondary ground water standard (0.05 mg/l) and the RBC (0.18 mg/l) for manganese. The total molybdenum and total vanadium concentration trends are

shown in Figures 3 and 4, respectively. Both concentration trends are decreasing with time from November 2003 to September 2004 with a slight increase in the concentration of both metals from September 2004 to March 2005. The total molybdenum concentration has decreased from March 2005 to June 2009. After the increase in vanadium concentration from September 2004 to March 2005, the vanadium concentration decreased through June 2006 and then increased through May 2007 and has decreased again through June 2009. The nitrate+nitrite concentration has been decreasing with time since March 2005 and is shown in Figure 5.

## **EV-2**

Table 2 compares the water quality observed in EV-2 and compares these results to the ground water quality standard. The total and dissolved arsenic concentrations are smaller than the primary drinking water standard of 0.05 mg/l. The water quality of the June 2009 sample does not exceed any of the primary ground water quality standards, but the water quality of this sample exceeds the secondary ground water quality standard for TDS. The total and dissolved aluminum concentration is smaller than the secondary ground water quality standard. The total and dissolved concentration of manganese did not exceed the secondary ground water standard.

Table 6 compares the measured metals concentrations from the sampling events to the RBC for each metal. The constituents exceeding the RBC at EV-2 in the May 2007 sample are total and dissolved molybdenum.

The total manganese concentration trend is shown on Figure 2. This trend continues to show decreasing concentrations and the total manganese concentration is smaller than the secondary ground water standard (0.05 mg/l) and the RBC (0.18 mg/l) for manganese. The total molybdenum and total vanadium concentration trends are shown in Figures 3 and 4, respectively. Both concentration trends are decreasing with time from November 2003 to June 2009. Figure 5 shows that the nitrate+nitrite concentration has not changed significantly with time and the concentration is less than the primary drinking water standard (10 mg/l).

## **EV-3**

Table 3 compares the water quality observed in EV-3 and compares these results to the ground water quality standard. The total and dissolved arsenic concentrations are smaller than the primary drinking water standard of 0.05 mg/l. The water quality of the June 2009 sample does not exceed any of the primary ground water quality standards. However, the water quality of this sample exceeds the secondary ground water quality standard for TDS, total aluminum and total manganese. The dissolved aluminum and manganese concentrations are smaller than the secondary ground water quality standards. The elevated total aluminum and manganese concentrations appear to be correlated to the elevated turbidity observed and measured in the sample.

Table 7 compares the measured metals concentrations from the sampling events to the RBC for each metal. The constituents exceeding the RBC at EV- 3 in the June 20 09 sample are total manganese and total and dissolved molybdenum.

The total manganese concentration trend is shown on Figure 2. The total manganese concentration is decreasing over time from September 2004 until June 2009 when the total manganese concentration increase significantly due to the increase in the turbidity of the water. The total molybdenum and total vanadium concentration trends are shown in Figures 3 and 4, respectively. The total molybdenum concentration trend is decreasing with time from November 2003 to June 2009. The total vanadium concentration is decreasing with time from November 2003 to March 2005, then increases slightly from March 2005 to June 2006, then decreases to June 2008 and increases slightly in June 2009. The nitrate+nitrite concentration trend with time shown in Figure 5 indicates that the nitrate+nitrite concentration has been decreasing from March 2005 to June 2008 and has increased slightly in June 2009, but remains smaller than the primary drinking water standard of 10 mg/l.

#### **EV-4**

Table 4 presents the water quality observed in EV-4 and compares these results to the ground water quality standard. The total and dissolved arsenic concentrations are smaller than the primary drinking water standard of 0.05 mg/l. The water quality of the June 2009 sample does not exceed any of the primary ground water quality standards. The water quality of this sample exceeds the secondary ground water quality standard for TDS. The total and dissolved concentrations of aluminum and manganese are less than the secondary ground water standard.

Table 8 compares the measured metals concentrations from the sampling event to the RBC for each metal. The constituents exceeding the RBC at EV- 4 in the June 20 09 sample are total and dissolved molybdenum and total and dissolved vanadium. The total manganese concentration trend is shown on Figure 2. The total manganese concentration is decreasing over time from September 2004. The total molybdenum and total vanadium concentration trends are shown in Figures 3 and 4, respectively. The total molybdenum concentration trend is decreasing with time from July 2004 to June 2009. The total vanadium concentration is decreasing with time from July 2004 to March 2005, then increases slightly from March 2005 to June 2006, then decreases again to June 2008 and then increases slightly in June 2009. Figure 5 shows that the nitrate+nitrite concentration has been decreasing since March 2005 to May 2007 and has increased slightly through June 2009.

#### **Ground Water Elevation**

The ground water elevation trend for each monitor well with time is shown in Figures 6-9 and the data is shown in Tables 9-12. The ground water elevation trends with time for monitor wells EV-1 and EV-2 shown on Figures 6 and 7, respectively, are almost

identical and show a recharge trend (i.e., increasing ground water elevations) from November 2003 to July 2004, then decreasing ground water elevations from July 2004 through December 2004, then a recharge trend from December 2004 to June 2006, then decreasing ground water elevations through June 2008 and a recharge trend through June 2009. The ground water elevations in EV-3 (Figure 8) and EV-4 (Figure 9) show decreasing ground water elevations from July 2004 to December 2004, then increasing ground water elevations from December 2004 to June 2006, then decreasing ground water elevations to June 2008 and then a recharge trend from June 2008 to June 2009.

The potentiometric levels shown in Figure 1 indicate that the ground water flow direction is west to west-southwest.

### Recommendations

It is recommended that this letter and the attachments be submitted to the Idaho Department of Environmental Quality (IDEQ). I am also available to discuss this information with them if you think this discussion is necessary.

It is also recommended that the ground water monitoring be continued on an annual basis. I recommend that the analyte list for the 2010 sampling event be revised to remove alkalinity, chloride, fluoride, total and dissolved calcium, total and dissolved magnesium, total and dissolved potassium and total and dissolved sodium.

Thank you for the opportunity to work on this project. If you have any questions regarding this information or the sampling program, please contact me.

Sincerely,  
**SPRAGUE ENVIRONMENTAL LLC**



Scott B. Sprague, P.E.  
Principal/Owner

SBS:sbs

Attachments

Table 1

City of Soda Springs - Evergreen Facility  
EV-1 Analytical Results

Constituent	Idaho Ground Water Quality Standard	29-Nov-03	15-Jul-04	29-Sep-04	26-Dec-04	20-Mar-05	2-Jun-06	28-May-07	29-Jun-08	2-Jun-09
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Alkalinity Bicarbonate as CaCO <sub>3</sub>	-	385	402	369	412	363	381	353	373	377
Alkalinity Carbonate as CaCO <sub>3</sub>	-	<2	<2	<2	<2	<2	23	<2	8	<2
Total Alkalinity as CaCO <sub>3</sub>	-	385	402	369	412	363	404	353	381	377
Chloride <sup>(2)</sup>	250	62	51	51.5	50	49	56	46.9	39.9	37.5
Conductivity @ 25 C	-	1040 umhos/cm	1130 umhos/cm	1020 umhos/cm	1060 umhos/cm	1160 umhos/cm	1190 umhos/cm	1080 umhos/cm	1090 umhos/cm	1050 umhos/cm
Fluoride <sup>(1)</sup>	4	0.3	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.3
Nitrate+Nitrite <sup>(1)</sup>	10	12.4	9.5	12.5	12.3	13.5	11.6	8.87	10.2	9.9
pH <sup>(2)</sup>	6.5-8.5	8.0	7.8	7.4	7.5	7.7	8.5	8.2	8.3	8.0
TDS <sup>(2)</sup>	500	720	639	670	740	740	700	680	640	650
Sulfate <sup>(2)</sup>	250	126	110	116	113	119	147	124	109	97
Turbidity	-	770 NTU	88.9 NTU	46.6 NTU	101 NTU	59.9 NTU	2.0 NTU	1.2 NTU	2.1 NTU	2.1 NTU
Aluminum, total <sup>(2)</sup>	0.2	11.00	4.13	2.07	4.74	0.66	0.19	0.04	0.26	0.06
Aluminum, dissolved	0.2	NA	NA	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic, total <sup>(1)</sup>	0.05	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.004	0.0039
Arsenic, dissolved	0.05	NA	NA	<0.04	<0.04	<0.04	<0.04	<0.04	0.0043	0.0046
Barium, total <sup>(1)</sup>	2	0.154	0.069	0.053	0.075	0.059	0.042	0.04	NA	NA
Barium, dissolved	2	NA	NA	0.034	0.039	0.036	0.041	0.038	NA	NA
Cadmium, total <sup>(1)</sup>	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Cadmium, dissolved	0.005	NA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Calcium, total	-	109	137	114	118	120	115	114	107	115
Calcium, dissolved	-	NA	NA	98.7	108	104	111	105	102	113
Chromium, total <sup>(1)</sup>	0.1	NA	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Chromium, dissolved	0.1	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, total	-	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Cobalt, dissolved	-	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Copper, total <sup>(1)</sup>	1.3	0.03	0.01	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Copper, dissolved	1.3	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Magnesium, total	-	NA	NA	39.6	41.2	41.2	40.7	39.6	38.6	41.3
Magnesium, dissolved	-	37.6	37.4	35.2	38.2	37.8	39.6	38.3	37.8	41.2
Manganese, total <sup>(2)</sup>	0.05	0.734	0.191	0.134	0.227	0.085	0.038	0.024	0.03	0.017
Manganese, dissolved	0.05	NA	NA	0.019	0.028	0.024	0.024	0.029	0.03	0.021
Molybdenum, total	-	0.92	0.74	0.73	0.75	0.76	0.71	0.66	0.63	0.57
Molybdenum, dissolved	-	NA	NA	0.72	0.74	0.70	0.68	0.65	0.61	0.55
Nickel, total	-	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Nickel, dissolved	-	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Potassium, total	-	NA	NA	9.2	10.3	9.3	8.4	8.1	7.6	7.6
Potassium, dissolved	-	9.1	9.2	8.1	9.0	8.6	8.2	7.6	7.1	7.8
Silver, total <sup>(2)</sup>	0.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Silver, dissolved	0.1	NA	NA	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Sodium, total	-	NA	NA	80.9	83.9	80.1	76.4	71.6	63.7	63
Sodium, dissolved	-	84.5	81.7	73.7	82.3	74.5	75.9	70.3	63.2	65.1
Vanadium, total	-	1.230	1.090	1.040	1.070	1.140	0.937	0.978	0.918	0.916
Vanadium, dissolved	-	NA	NA	0.980	1.030	1.000	0.911	0.927	0.927	0.99

Shaded area indicates an exceedence of the Idaho Ground Water Quality Standard

(1) IDAPA 58.01.11 - Ground Water Quality Rule, primary standard

(2) IDAPA 58.01.11 - Ground Water Quality Rule, secondary standard

NA - Not Analyzed

Table 2

City of Soda Springs - Evergreen Facility  
EV-2 Analytical Results

Idaho Ground Water Quality		29-Nov-03	15-Jul-04	29-Sep-04	26-Dec-04	20-Mar-05	2-Jun-06	28-May-07	29-Jun-08	2-Jun-09
Constituent	Standard (mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Alkalinity Bicarbonate as CaCO <sub>3</sub>	-	398	430	406	417	390	329	379	407	399
Alkalinity Carbonate as CaCO <sub>3</sub>	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Alkalinity as CaCO <sub>3</sub>	-	398	430	406	417	390	329	379	407	399
Chloride <sup>(2)</sup>	250	50.4	47.1	45.6	44.8	39.0	41.2	33.9	30.0	28.9
Conductivity @ 25 C	-	862 umhos/cm	1040 umhos/cm	889 umhos/cm	884 umhos/cm	1020 umhos/cm	915 umhos/cm	928 umhos/cm	961 umhos/cm	926 umhos/cm
Fluoride <sup>(1)</sup>	4	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.3
Nitrate+Nitrite <sup>(1)</sup>	10	3.88	3.45	3.61	3.60	3.54	4.71	3.43	3.76	3.84
pH <sup>(2)</sup>	6.5-8.5	8.0	7.9	7.3	7.8	7.7	8.3	8.1	8.3	8.0
TDS <sup>(2)</sup>	500	620	595	590	610	600	580	580	560	560
Sulfate <sup>(2)</sup>	250	86.9	74.0	85.0	79.8	74.0	77.6	71.9	63.9	64.1
Turbidity	-	690 NTU	928 NTU	445 NTU	305 NTU	341 NTU	9.2 NTU	1.5 NTU	4.6 NTU	2.0 NTU
Aluminum, total <sup>(2)</sup>	0.2	33.00	27.10	22.6	18.3	14.2	1.59	0.63	0.84	0.15
Aluminum, dissolved	0.2	NA	NA	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03
Arsenic, total <sup>(1)</sup>	0.05	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.0011	0.0009
Arsenic, dissolved	0.05	NA	NA	<0.04	<0.04	<0.04	<0.04	<0.04	0.0008	0.001
Barium, total <sup>(1)</sup>	2	0.230	0.169	0.158	0.139	0.139	0.061	0.053	NA	NA
Barium, dissolved	2	NA	NA	0.049	0.051	0.048	0.050	0.048	NA	NA
Cadmium, total <sup>(1)</sup>	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Cadmium, dissolved	0.005	NA	NA	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Calcium, total	-	121	137	142	129	147	111	113	110	116
Calcium, dissolved	-	NA	NA	101	107	105	105	102	101	112
Chromium, total <sup>(1)</sup>	0.1	NA	0.04	0.03	0.02	<0.05	<0.01	<0.01	NA	NA
Chromium, dissolved	0.1	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, total	-	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, dissolved	-	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Copper, total <sup>(1)</sup>	1.3	0.05	0.02	0.02	0.01	0.01	<0.01	<0.01	NA	NA
Copper, dissolved	1.3	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Magnesium, total	-	NA	NA	56.1	51.5	58.0	43.5	43.1	42.3	44.2
Magnesium, dissolved	-	44.0	40.7	38.8	40.9	40.9	40.5	41.1	39.1	42.8
Manganese, total <sup>(2)</sup>	0.05	0.605	0.306	0.289	0.206	0.238	0.024	0.008	0.008	<0.005
Manganese, dissolved	0.05	NA	NA	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum, total	-	0.40	0.37	0.35	0.34	0.36	0.30	0.30	0.28	0.25
Molybdenum, dissolved	-	NA	NA	0.35	0.34	0.34	0.29	0.29	0.27	0.25
Nickel, total	-	0.03	0.03	0.03	0.02	0.02	<0.01	<0.01	NA	NA
Nickel, dissolved	-	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Potassium, total	-	NA	NA	8.1	7.6	8.8	4.5	4.6	4.2	4.1
Potassium, dissolved	-	4.9	4.7	4.2	4.4	4.3	4.1	3.9	3.5	4.0
Silver, total <sup>(2)</sup>	0.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Silver, dissolved	0.1	NA	NA	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Sodium, total	-	NA	NA	61.7	60.0	58.7	55.4	50.3	45.2	45
Sodium, dissolved	-	70.9	62.3	55.9	58.9	55.3	52.7	49.6	42.6	45
Vanadium, total	-	0.280	0.251	0.242	0.226	0.246	0.179	0.187	0.180	0.174
Vanadium, dissolved	-	NA	NA	0.180	0.181	0.181	0.165	0.173	0.168	0.181

Shaded area indicates an exceedence of the Idaho Ground Water Quality Standard

(1) IDAPA 58.01.11 - Ground Water Quality Rule, primary standard

(2) IDAPA 58.01.11 - Ground Water Quality Rule, secondary standard

NA - Not Analyzed



Table 3

City of Soda Springs - Evergreen Facility  
EV-3 Analytical Results

Idaho Ground Water Quality		29-Nov-03	15-Jul-04	29-Sep-04	26-Dec-04	20-Mar-05	2-Jun-06	28-May-07	29-Jun-08	2-Jun-09
Constituent	Standard (mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Alkalinity Bicarbonate as CaCO <sub>3</sub>	-	403	420	399	418	367	374	345	402	405
Alkalinity Carbonate as CaCO <sub>3</sub>	-	<2	<2	<2	<2	<2	56	<2	<2	<2
Total Alkalinity as CaCO <sub>3</sub>	-	403	420	399	418	367	431	345	402	405
Chloride <sup>(2)</sup>	250	54	48.4	46.3	46.1	48.0	44.5	34.9	31.2	32.8
Conductivity @ 25 C	-	879 umhos/cm	1050 umhos/cm	900 umhos/cm	914 umhos/cm	1320 umhos/cm	1130 umhos/cm	942 umhos/cm	977 umhos/cm	977 umhos/cm
Fluoride <sup>(1)</sup>	4	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.3
Nitrate+Nitrite <sup>(1)</sup>	10	5.4	4.6	<0.02	6.08	25.3	6.91	5.26	5.6	7.76
pH <sup>(2)</sup>	6.5-8.5	8.1	7.8	7.2	7.7	7.7	8.6	8.2	8.3	8.0
TDS <sup>(2)</sup>	500	640	601	620	630	870	610	610	590	610
Sulfate <sup>(2)</sup>	250	88.5	79.5	89.3	87.5	131	97.9	78.3	69.9	79.6
Turbidity	-	262 NTU	65.3 NTU	165 NTU	96.3 NTU	29.9 NTU	8.3 NTU	2.4 NTU	19.2 NTU	95.2 NTU
Aluminum, total <sup>(2)</sup>	0.2	17.20	6.22	10.30	6.07	2.27	1.97	0.89	1.61	10.6
Aluminum, dissolved	0.2	NA	NA	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03
Arsenic, total <sup>(1)</sup>	0.05	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.0017	0.0025
Arsenic, dissolved	0.05	NA	NA	<0.04	<0.04	<0.04	<0.04	<0.04	0.0013	0.0011
Barium, total <sup>(1)</sup>	2	0.164	0.101	0.137	0.102	0.089	0.078	0.059	NA	NA
Barium, dissolved	2	NA	NA	0.050	0.056	0.065	0.057	0.049	NA	NA
Cadmium, total <sup>(1)</sup>	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Cadmium, dissolved	0.005	NA	NA	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Calcium, total	-	117	115	120	115	142	120	114	110	119
Calcium, dissolved	-	NA	NA	101	110	134	107	104	105	117
Chromium, total <sup>(1)</sup>	0.1	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Chromium, dissolved	0.1	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, total	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, dissolved	-	NA	NA	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Copper, total <sup>(1)</sup>	1.3	0.02	0.02	0.01	0.01	<0.01	<0.01	<0.01	NA	NA
Copper, dissolved	1.3	NA	NA	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Magnesium, total	-	NA	NA	45.7	44.2	53.7	48.9	42.1	42.4	47.4
Magnesium, dissolved	-	42.4	41.1	35.5	41.9	52.5	43.1	44.2	41.1	46
Manganese, total <sup>(2)</sup>	0.05	0.553	0.349	0.694	0.344	0.152	0.124	0.063	0.098	0.483
Manganese, dissolved	0.05	NA	NA	0.025	0.016	0.016	0.011	0.016	0.007	0.007
Molybdenum, total	-	0.44	0.37	0.36	0.35	0.36	0.34	0.31	0.3	0.28
Molybdenum, dissolved	-	NA	NA	0.35	0.35	0.34	0.33	0.3	0.27	0.27
Nickel, total	-	0.05	0.04	0.05	0.03	0.03	0.03	0.02	NA	NA
Nickel, dissolved	-	NA	NA	0.02	0.02	0.02	0.02	0.02	NA	NA
Potassium, total	-	NA	NA	6.1	5.7	5.5	6.7	4.6	4.5	6
Potassium, dissolved	-	5.0	5.3	4.4	4.6	4.8	5.9	4.4	3.9	4.7
Silver, total <sup>(2)</sup>	0.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Silver, dissolved	0.1	NA	NA	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Sodium, total	-	NA	NA	64.1	63.1	69.7	66.4	52.9	47.5	51.2
Sodium, dissolved	-	72.8	65.3	56.4	61.7	66.1	60.5	51.8	47.0	53.0
Vanadium, total	-	0.227	0.196	0.216	0.195	0.181	0.352	0.257	0.208	0.247
Vanadium, dissolved	-	NA	NA	0.159	0.165	0.158	0.325	0.234	0.193	0.210

Shaded area indicates an exceedence of the Idaho Ground Water Quality Standard

(1) IDAPA 58.01.11 - Ground Water Quality Rule, primary standard

(2) IDAPA 58.01.11 - Ground Water Quality Rule, secondary standard

NA - Not Analyzed

Table 4

City of Soda Springs - Evergreen Facility  
EV-4 Analytical Results

Constituent	Idaho Ground Water Quality Standard (mg/l)	29-Nov-03 (mg/l)	15-Jul-04 (mg/l)	29-Sep-04 (mg/l)	26-Dec-04 (mg/l)	20-Mar-05 (mg/l)	2-Jun-06 (mg/l)	28-May-07 (mg/l)	29-Jun-08 (mg/l)	2-Jun-09 (mg/l)
Alkalinity Bicarbonate as CaCO <sub>3</sub>	-	Not Sampled	427	402	385	373	378	374	399	390
Alkalinity Carbonate as CaCO <sub>3</sub>	-	Well Not Drilled	<2	<2	<2	<2	28	<2	<2	<2
Total Alkalinity as CaCO <sub>3</sub>	-		427	402	385	373	407	374	399	390
Chloride <sup>(2)</sup>	250		50.0	52.8	46.0	51.0	53.2	41.2	37.6	38.8
Conductivity @ 25 C	-		1130 umhos/cm	1010 umhos/cm	993 umhos/cm	1220 umhos/cm	1060 umhos/cm	1020 umhos/cm	1050 umhos/cm	1040 umhos/cm
Fluoride <sup>(1)</sup>	4		0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.3
Nitrate+Nitrite <sup>(1)</sup>	10		5.6	6.68	8.18	15.2	13.1	6.91	7.86	9.4
pH <sup>(2)</sup>	6.5-8.5		7.8	7.2	7.6	7.7	8.5	8.2	8.2	7.5
TDS <sup>(2)</sup>	500		639	660	680	750	710	650	760	660
Sulfate <sup>(2)</sup>	250		97.9	113	111	107	133	99.8	88.1	95
Turbidity	-		8.5 NTU	3.1 NTU	1.4 NTU	0.8 NTU	0.5 NTU	1.9 NTU	1.4 NTU	5.1 NTU
Aluminum, total <sup>(2)</sup>	0.2		1.89	0.36	0.06	0.08	0.04	<0.03	0.03	<0.03
Aluminum, dissolved	0.2		NA	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic, total <sup>(1)</sup>	0.05		<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.0021	0.0015
Arsenic, dissolved	0.05		NA	<0.04	<0.04	<0.04	<0.04	<0.04	0.0017	0.0016
Barium, total <sup>(1)</sup>	2		0.066	0.049	0.048	0.052	0.050	0.049	NA	NA
Barium, dissolved	2		NA	0.045	0.049	0.049	0.046	0.047	NA	NA
Cadmium, total <sup>(1)</sup>	0.005		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Cadmium, dissolved	0.005		NA	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Calcium, total	-		115	113	115	123	127	120	109	118
Calcium, dissolved	-		NA	107	112	116	114	108	104	115
Chromium, total <sup>(1)</sup>	0.1		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Chromium, dissolved	0.1		NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, total	-		<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Cobalt, dissolved	-		NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Copper, total <sup>(1)</sup>	1.3		0.02	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Copper, dissolved	1.3		NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Magnesium, total	-		NA	42.8	43.5	46.4	48.7	43.6	41.8	15.5
Magnesium, dissolved	-		41.6	40.6	42.5	45.6	44.0	41.5	40.4	44.4
Manganese, total <sup>(2)</sup>	0.05		0.045	0.025	0.019	0.017	0.025	0.017	0.012	0.011
Manganese, dissolved	0.05		NA	0.016	0.017	0.015	0.022	0.022	0.011	<0.005
Molybdenum, total	-		0.49	0.47	0.47	0.47	0.48	0.44	0.40	0.40
Molybdenum, dissolved	-		NA	0.46	0.46	0.45	0.45	0.41	0.40	0.37
Nickel, total	-		0.02	0.01	0.01	0.02	0.01	0.01	NA	NA
Nickel, dissolved	-		NA	0.01	<0.01	0.01	0.01	<0.01	NA	NA
Potassium, total	-		NA	5.9	6.3	6.3	7.0	5.8	5.4	5.7
Potassium, dissolved	-		6.3	5.7	6.0	6.2	6.6	5.5	5	5.4
Silver, total <sup>(2)</sup>	0.1		<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Silver, dissolved	0.1		NA	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Sodium, total	-		NA	73.5	74.4	75.7	76.9	62.9	57.4	60.6
Sodium, dissolved	-		75.7	67.8	71.8	70.7	71.8	60.8	55.7	58.7
Vanadium, total	-		0.352	0.333	0.334	0.331	0.499	0.41	0.332	0.354
Vanadium, dissolved	-		NA	0.320	0.324	0.316	0.488	0.385	0.332	0.347

Shaded area indicates an exceedence of the Idaho Ground Water Quality Standard

(1) IDAPA 58.01.11 - Ground Water Quality Rule, primary standard

(2) IDAPA 58.01.11 - Ground Water Quality Rule, secondary standard

NA - Not Analyzed

Table 5

City of Soda Springs - Evergreen Facility  
EV-1 Analytical Results

<u>Constituent</u>	<u>Risk-Based Concentration<sup>(1)</sup> (mg/l)</u>	<u>29-Nov-03 (mg/l)</u>	<u>15-Jul-04 (mg/l)</u>	<u>29-Sep-04 (mg/l)</u>	<u>26-Dec-04 (mg/l)</u>	<u>20-Mar-05 (mg/l)</u>	<u>2-Jun-06 (mg/l)</u>	<u>28-May-07 (mg/l)</u>	<u>29-Jun-08 (mg/l)</u>	<u>2-Jun-09 (mg/l)</u>
Aluminum, total	36	11.00	4.13	2.07	4.74	0.66	0.19	0.04	0.26	0.06
Aluminum, dissolved	36	NA	NA	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic, total	0.011	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.004	0.0039
Arsenic, dissolved	0.011	NA	NA	<0.04	<0.04	<0.04	<0.04	<0.04	0.0043	0.0046
Barium, total	2.6	0.154	0.069	0.053	0.075	0.059	0.042	0.04	NA	NA
Barium, dissolved	2.6	NA	NA	0.034	0.039	0.036	0.041	0.038	NA	NA
Cadmium, total	0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Cadmium, dissolved	0.019	NA	NA	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Chromium, total	0.36	NA	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Chromium, dissolved	0.36	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, total	0.91	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Cobalt, dissolved	0.91	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Copper, total	1.4	0.03	0.01	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Copper, dissolved	1.4	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Manganese, total	0.18	0.734	0.191	0.134	0.227	0.085	0.038	0.024	0.03	0.017
Manganese, dissolved	0.18	NA	NA	0.019	0.028	0.024	0.024	0.029	0.03	0.02
Molybdenum, total	0.18	0.92	0.74	0.73	0.75	0.76	0.71	0.66	0.63	0.57
Molybdenum, dissolved	0.18	NA	NA	0.72	0.74	0.70	0.68	0.65	0.61	0.55
Nickel, total	0.73	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Nickel, dissolved	0.73	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Silver, total	0.18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Silver, dissolved	0.18	NA	NA	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Vanadium, total	0.26	1.230	1.090	1.040	1.070	1.140	0.937	0.978	0.918	0.916
Vanadium, dissolved	0.26	NA	NA	0.980	1.030	1.000	0.911	0.927	0.927	0.99

Shaded area indicates an exceedence of the risk-based concentration

(1) SAIC; Draft Human Health and Ecological Risk Assessments for  
Kerr-McGee Chemical Corporation; Soda Springs, Idaho; October 1993.

NA - Not Analyzed

Table 6

City of Soda Springs - Evergreen Facility  
EV-2 Analytical Results

<u>Constituent</u>	<u>Risk-Based Concentration<sup>(1)</sup> (mg/l)</u>	<u>29-Nov-03 (mg/l)</u>	<u>15-Jul-04 (mg/l)</u>	<u>29-Sep-04 (mg/l)</u>	<u>26-Dec-04 (mg/l)</u>	<u>20-Mar-05 (mg/l)</u>	<u>2-Jun-06 (mg/l)</u>	<u>28-May-07 (mg/l)</u>	<u>29-Jun-08 (mg/l)</u>	<u>2-Jun-09 (mg/l)</u>
Aluminum, total	36	33.00	27.10	22.6	18.3	14.2	1.59	0.63	0.84	0.15
Aluminum, dissolved	36	NA	NA	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03
Arsenic, total	0.011	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.0011	0.0009
Arsenic, dissolved	0.011	NA	NA	<0.04	<0.04	<0.04	<0.04	<0.04	0.0008	0.001
Barium, total	2.6	0.230	0.169	0.158	0.139	0.139	0.061	0.053	NA	NA
Barium, dissolved	2.6	NA	NA	0.049	0.051	0.048	0.050	0.048	NA	NA
Cadmium, total	0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Cadmium, dissolved	0.019	NA	NA	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Chromium, total	0.36	NA	0.04	0.03	0.02	<0.05	<0.01	<0.01	NA	NA
Chromium, dissolved	0.36	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, total	0.91	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, dissolved	0.91	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Copper, total	1.4	0.05	0.02	0.02	0.01	0.01	<0.01	<0.01	NA	NA
Copper, dissolved	1.4	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Manganese, total	0.18	0.605	0.306	0.289	0.206	0.238	0.024	0.008	0.008	<0.005
Manganese, dissolved	0.18	NA	NA	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum, total	0.18	0.40	0.37	0.35	0.34	0.36	0.30	0.30	0.28	0.25
Molybdenum, dissolved	0.18	NA	NA	0.35	0.34	0.34	0.29	0.29	0.27	0.25
Nickel, total	0.73	0.03	0.03	0.03	0.02	0.02	<0.01	<0.01	NA	NA
Nickel, dissolved	0.73	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Silver, total	0.18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Silver, dissolved	0.18	NA	NA	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Vanadium, total	0.26	0.280	0.251	0.242	0.226	0.246	0.179	0.187	0.180	0.174
Vanadium, dissolved	0.26	NA	NA	0.180	0.181	0.181	0.165	0.173	0.168	0.181

Shaded area indicates an exceedence of the risk-based concentration

(1) SAIC; Draft Human Health and Ecological Risk Assessments for  
Kerr-McGee Chemical Corporation; Soda Springs, Idaho; October 1993.

NA - Not Analyzed

Table 7

City of Soda Springs - Evergreen Facility  
EV-3 Analytical Results

<u>Constituent</u>	<u>Risk-Based Concentration<sup>(1)</sup> (mg/l)</u>	<u>29-Nov-03 (mg/l)</u>	<u>15-Jul-04 (mg/l)</u>	<u>29-Sep-04 (mg/l)</u>	<u>26-Dec-04 (mg/l)</u>	<u>20-Mar-05 (mg/l)</u>	<u>2-Jun-06 (mg/l)</u>	<u>28-May-07 (mg/l)</u>	<u>29-Jun-08 (mg/l)</u>	<u>2-Jun-09 (mg/l)</u>
Aluminum, total	36	17.20	6.22	10.30	6.07	2.27	1.97	0.89	1.61	10.6
Aluminum, dissolved	36	NA	NA	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03
Arsenic, total	0.011	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.0017	0.0025
Arsenic, dissolved	0.011	NA	NA	<0.04	<0.04	<0.04	<0.04	<0.04	0.0013	0.0011
Barium, total	2.6	0.164	0.101	0.137	0.102	0.089	0.078	0.059	NA	NA
Barium, dissolved	2.6	NA	NA	0.050	0.056	0.065	0.057	0.049	NA	NA
Cadmium, total	0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Cadmium, dissolved	0.019	NA	NA	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Chromium, total	0.36	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Chromium, dissolved	0.36	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, total	0.91	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Cobalt, dissolved	0.91	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Copper, total	1.4	0.02	0.02	0.01	0.01	<0.02	<0.01	<0.01	NA	NA
Copper, dissolved	1.4	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Manganese, total	0.18	0.553	0.349	0.694	0.344	0.152	0.124	0.063	0.098	0.483
Manganese, dissolved	0.18	NA	NA	0.025	0.016	0.016	0.011	0.016	0.007	0.007
Molybdenum, total	0.18	0.44	0.37	0.36	0.35	0.36	0.34	0.31	0.30	0.28
Molybdenum, dissolved	0.18	NA	NA	0.35	0.35	0.34	0.33	0.30	0.27	0.27
Nickel, total	0.73	0.05	0.04	0.05	0.03	0.03	0.03	0.02	NA	NA
Nickel, dissolved	0.73	NA	NA	0.02	0.02	0.02	0.02	0.02	NA	NA
Silver, total	0.18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Silver, dissolved	0.18	NA	NA	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Vanadium, total	0.26	0.227	0.196	0.216	0.195	0.181	0.352	0.257	0.208	0.247
Vanadium, dissolved	0.26	NA	NA	0.159	0.165	0.158	0.325	0.234	0.193	0.210

Shaded area indicates an exceedence of the risk-based concentration  
(1) SAIC; Draft Human Health and Ecological Risk Assessments for  
Kerr-McGee Chemical Corporation; Soda Springs, Idaho; October 1993.

NA - Not Analyzed

Table 8

City of Soda Springs - Evergreen Facility  
EV-4 Analytical Results

<u>Constituent</u>	<u>Risk-Based Concentration<sup>(1)</sup> (mg/l)</u>	<u>29-Nov-03 (mg/l)</u>	<u>15-Jul-04 (mg/l)</u>	<u>29-Sep-04 (mg/l)</u>	<u>26-Dec-04 (mg/l)</u>	<u>20-Mar-05 (mg/l)</u>	<u>2-Jun-06 (mg/l)</u>	<u>28-May-07 (mg/l)</u>	<u>29-Jun-08 (mg/l)</u>	<u>2-Jun-09 (mg/l)</u>
Aluminum, total	36	Not Sampled	1.89	0.36	0.06	0.08	0.04	<0.03	0.03	<0.03
Aluminum, dissolved	36	Well Not	NA	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic, total	0.011	Drilled	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.0021	0.0015
Arsenic, dissolved	0.011		NA	<0.04	<0.04	<0.04	<0.04	<0.04	0.0017	0.0016
Barium, total	2.6		0.066	0.049	0.048	0.052	0.050	0.049	NA	NA
Barium, dissolved	2.6		NA	0.045	0.049	0.049	0.046	0.047	NA	NA
Cadmium, total	0.019		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Cadmium, dissolved	0.019		NA	<0.005	<0.005	<0.005	<0.005	<0.005	NA	NA
Chromium, total	0.36		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Chromium, dissolved	0.36		NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Cobalt, total	0.91		<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Cobalt, dissolved	0.91		NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Copper, total	1.4		0.02	<0.01	<0.01	<0.02	<0.01	<0.01	NA	NA
Copper, dissolved	1.4		NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Manganese, total	0.18		0.045	0.025	0.019	0.017	0.025	0.017	0.012	0.011
Manganese, dissolved	0.18		NA	0.016	0.017	0.015	0.022	0.022	0.011	<0.005
Molybdenum, total	0.18		0.49	0.47	0.47	0.47	0.47	0.44	0.40	0.40
Molybdenum, dissolved	0.18		NA	0.46	0.46	0.45	0.45	0.41	0.40	0.37
Nickel, total	0.73		0.02	0.01	0.01	0.02	0.01	0.01	NA	NA
Nickel, dissolved	0.73		NA	0.01	<0.01	0.01	0.01	<0.01	NA	NA
Silver, total	0.18		<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Silver, dissolved	0.18		NA	<0.005	<0.005	<0.005	<0.01	<0.01	NA	NA
Vanadium, total	0.26		0.352	0.333	0.334	0.331	0.499	0.41	0.332	0.354
Vanadium, dissolved	0.26		NA	0.320	0.324	0.316	0.488	0.385	0.332	0.347

Shaded area indicates an exceedence of the risk-based concentration

(1) SAIC; Draft Human Health and Ecological Risk Assessments for  
Kerr-McGee Chemical Corporation; Soda Springs, Idaho; October 1993.

NA - Not Analyzed

Table 9

City of Soda Springs - Evergreen Facility  
EV-1 Ground Water Elevation

Top of Casing Elevation (ft MSL): 5,951.00

<u>Date</u>	<u>Depth to Water (ft)</u>	<u>Ground Water Elevation (ft MSL)</u>
29-Nov-03	21.45	5,929.55
15-Jul-04	21.12	5,929.88
29-Sep-04	22.14	5,928.86
26-Dec-04	22.28	5,928.72
20-Mar-05	20.62	5,930.38
2-Jun-06	19.11	5,931.89
28-May-07	20.22	5,930.78
29-Jun-08	20.42	5,930.58
2-Jun-09	19.78	5,931.22

Table 10

City of Soda Springs - Evergreen Facility  
EV-2 Ground Water Elevation

Top of Casing Elevation (ft MSL): 5,943.00

<u>Date</u>	<u>Depth to Water (ft)</u>	<u>Ground Water Elevation (ft MSL)</u>
29-Nov-03	13.83	5,929.17
15-Jul-04	13.63	5,929.37
29-Sep-04	14.13	5,928.87
26-Dec-04	14.22	5,928.78
20-Mar-05	12.98	5,930.02
2-Jun-06	12.01	5,930.99
28-May-07	12.53	5,930.47
29-Jun-08	12.63	5,930.37
2-Jun-09	12.24	5,930.76



Table 11

City of Soda Springs - Evergreen Facility  
EV-3 Ground Water Elevation

Top of Casing Elevation (ft MSL): 5,938.00

<u>Date</u>	<u>Depth to Water (ft)</u>	<u>Ground Water Elevation (ft MSL)</u>
15-Jul-04	22.09	5,915.91
29-Sep-04	24.02	5,913.98
26-Dec-04	24.56	5,913.44
20-Mar-05	20.57	5,917.43
2-Jun-06	18.53	5,919.47
28-May-07	19.84	5,918.16
29-Jun-08	20.32	5,917.68
2-Jun-09	19.42	5,918.58

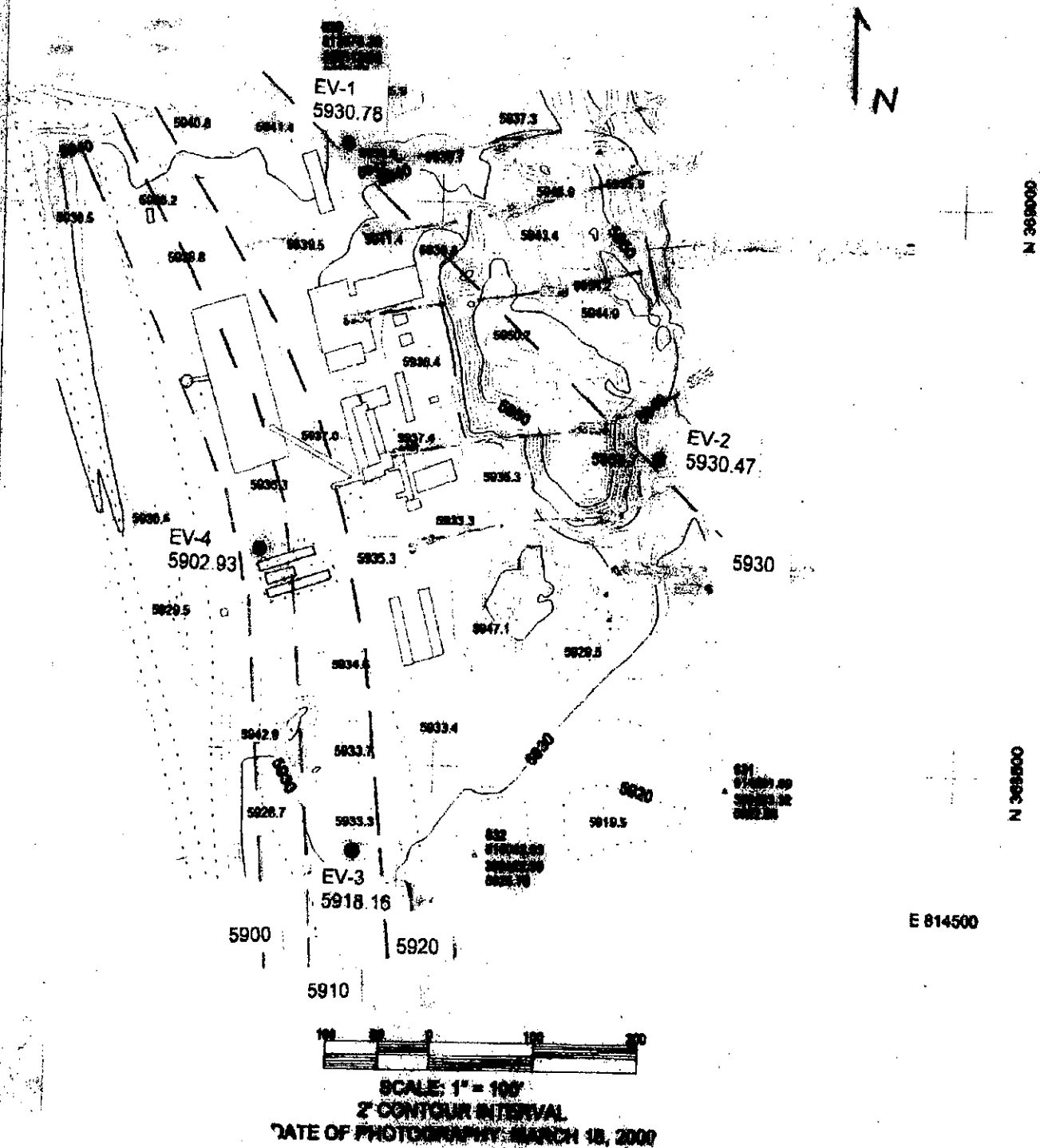
Table 12

City of Soda Springs - Evergreen Facility  
EV-4 Ground Water Elevation

Top of Casing Elevation (ft MSL): 5,945.00

<u>Date</u>	<u>Depth to Water (ft)</u>	<u>Ground Water Elevation (ft MSL)</u>
15-Jul-04	43.76	5,901.24
29-Sep-04	44.79	5,900.21
26-Dec-04	44.86	5,900.14
20-Mar-05	42.79	5,902.21
2-Jun-06	41.08	5,903.92
28-May-07	42.07	5,902.93
29-Jun-08	42.65	5,902.35
2-Jun-09	41.86	5,903.14

### Figure 1



**Figure 2**  
**Total Manganese Concentration Trend**

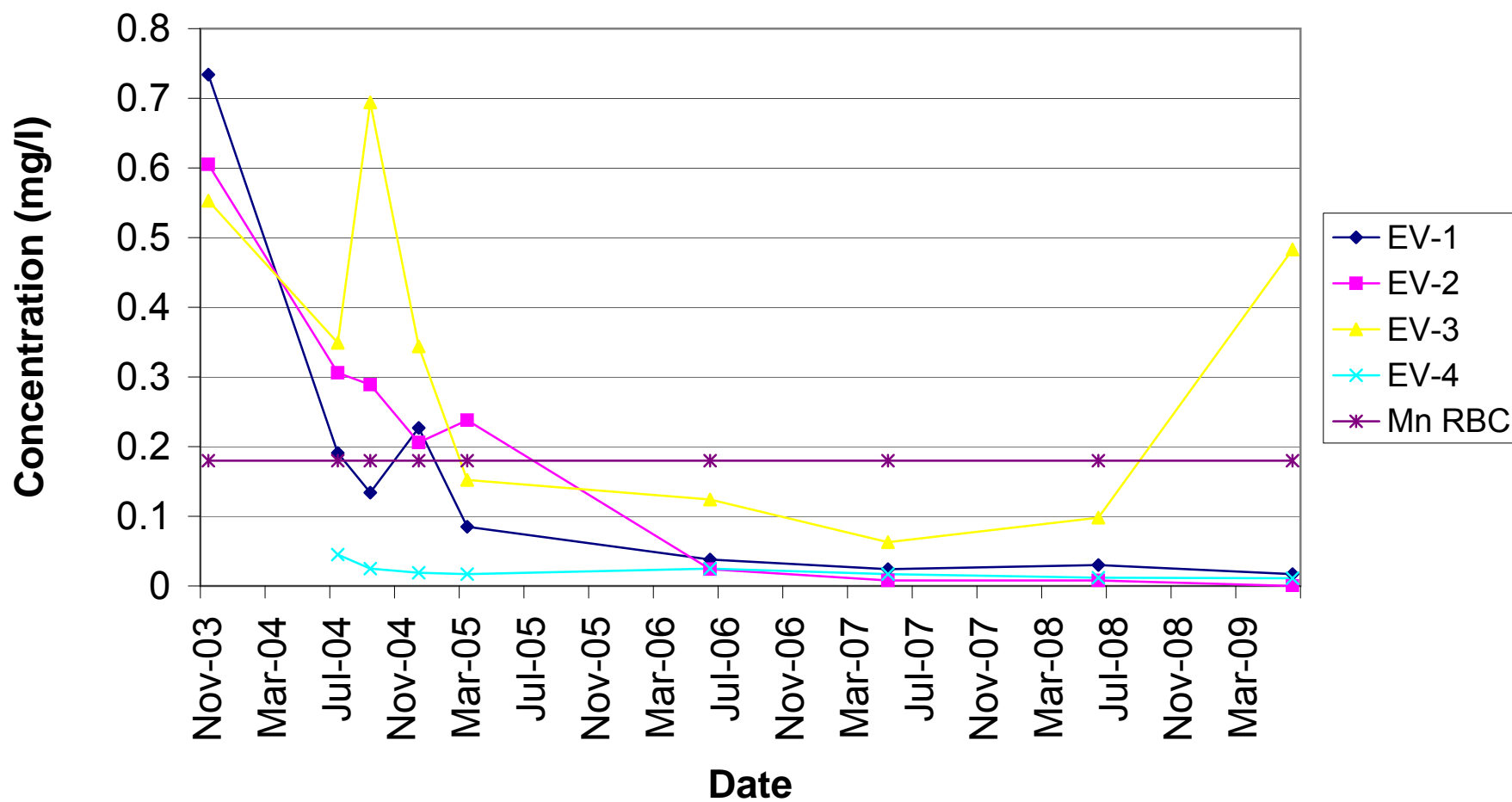


Figure 3

## Total Molybdenum Concentration Trend

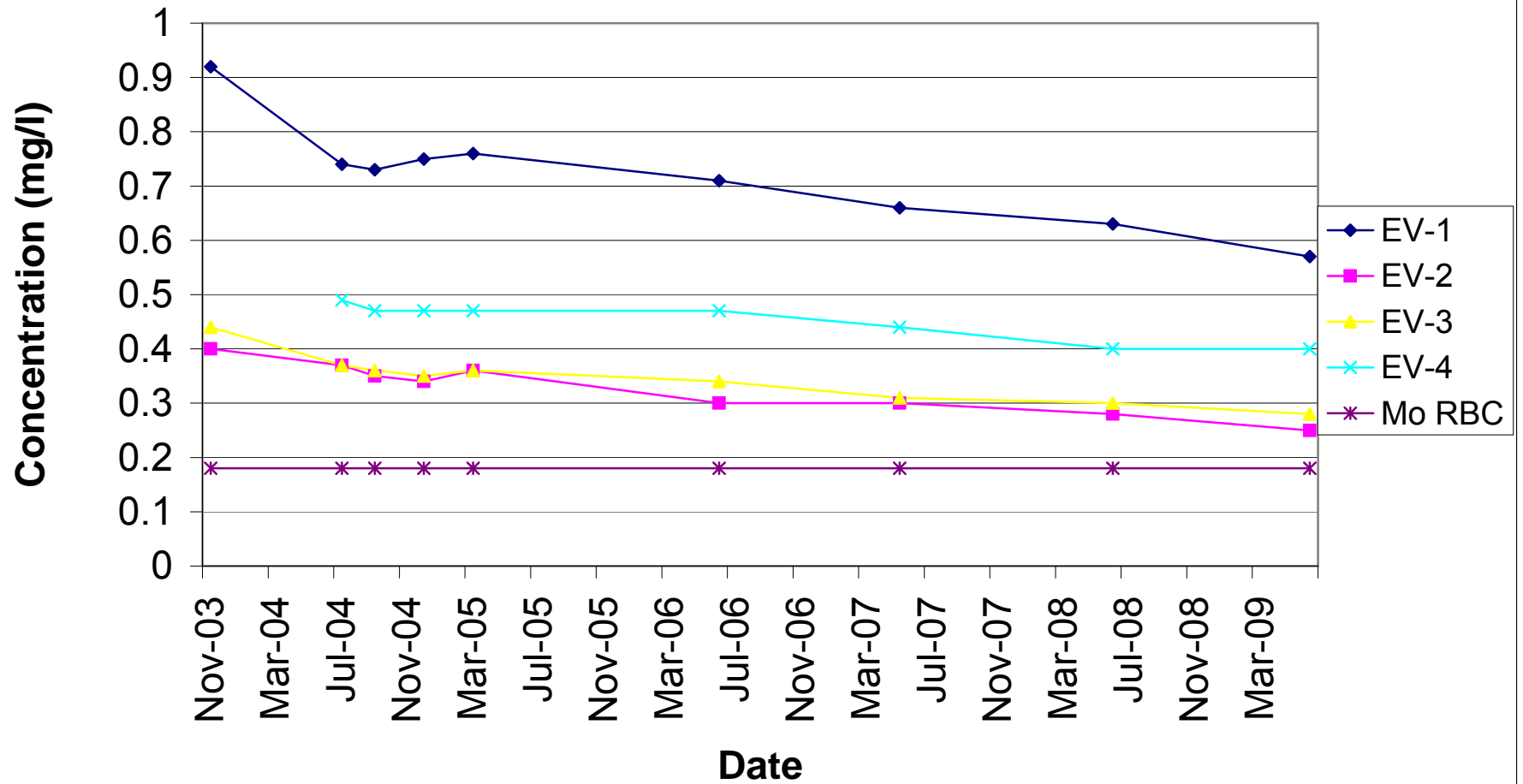
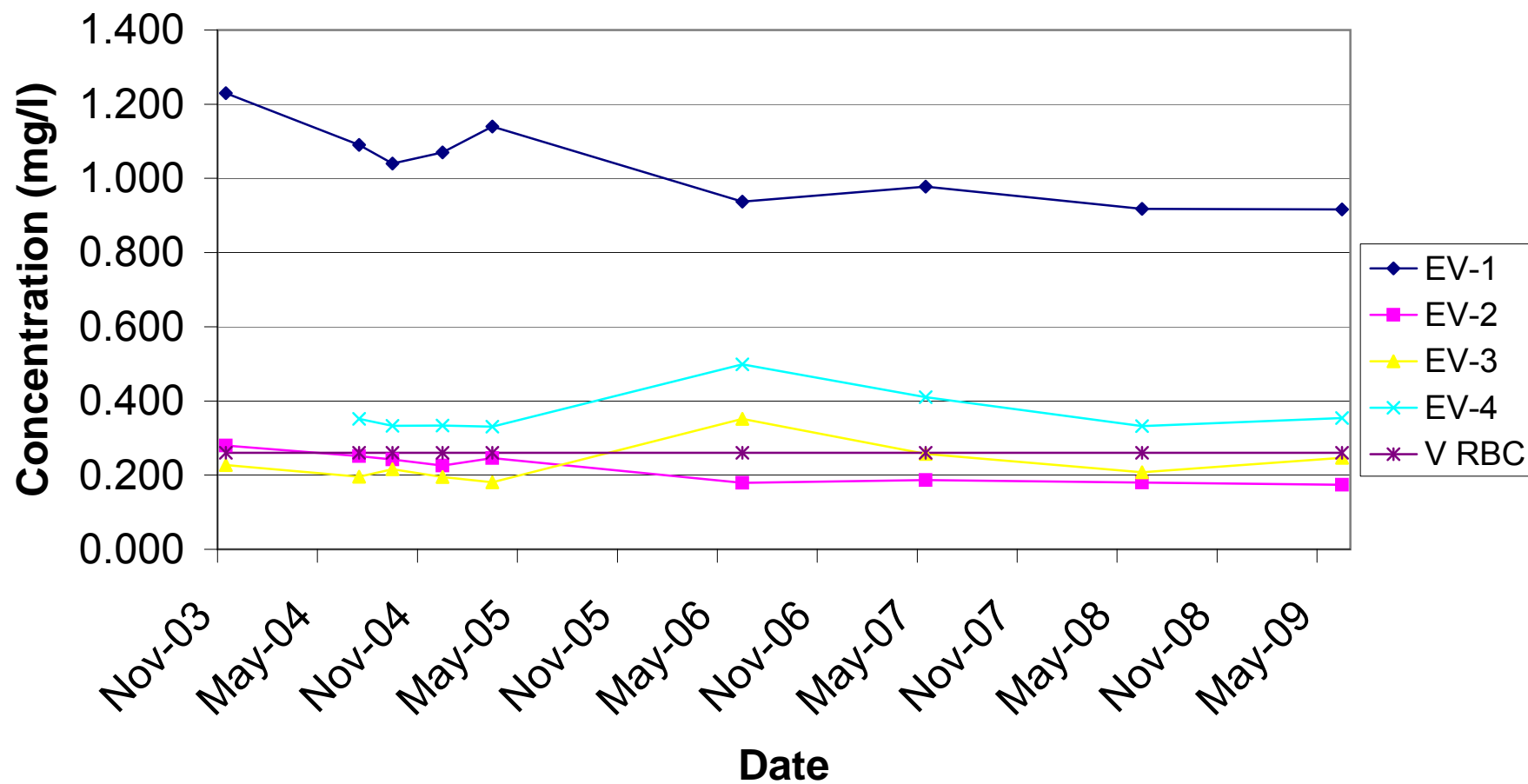
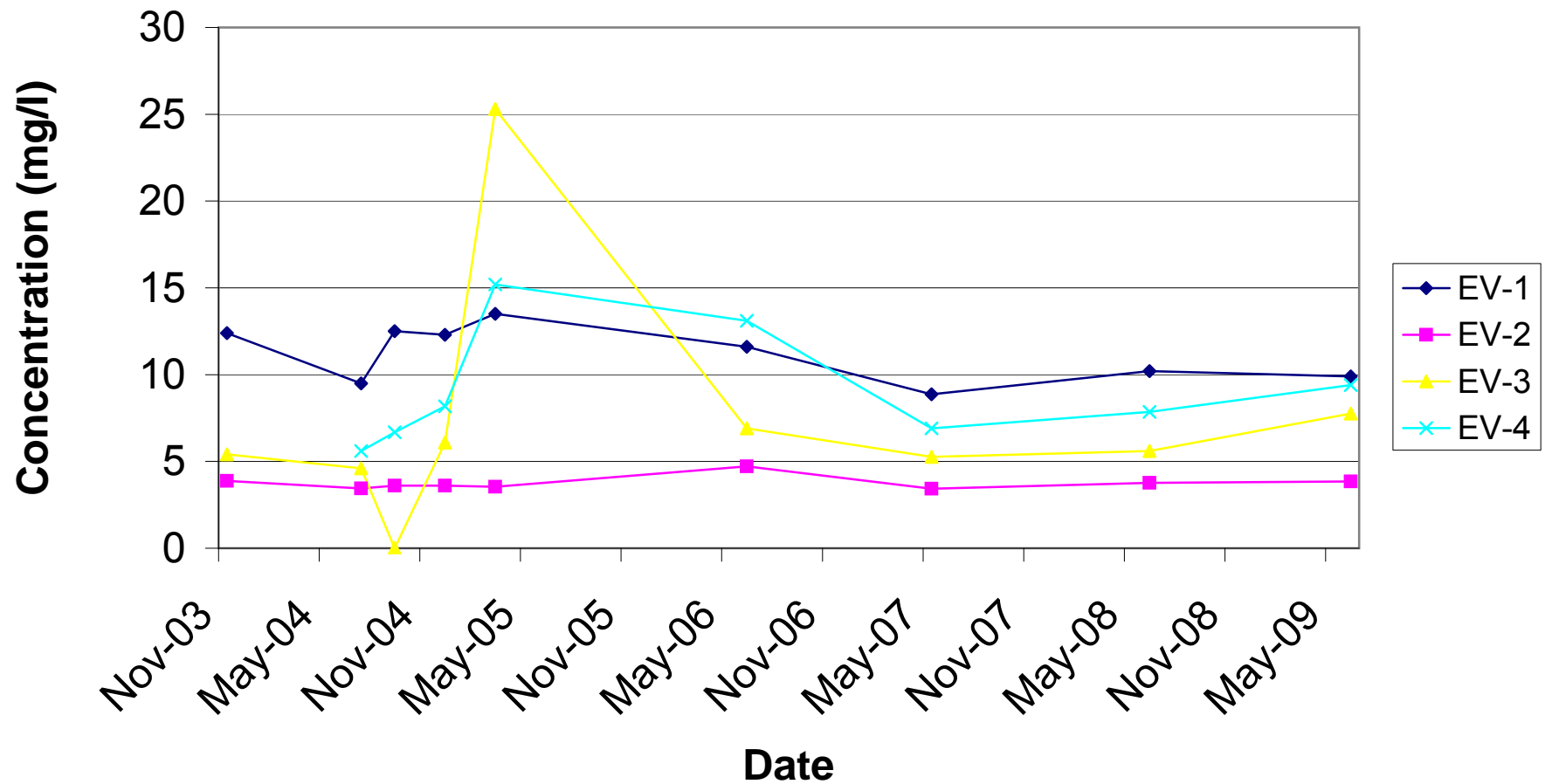


Figure 4

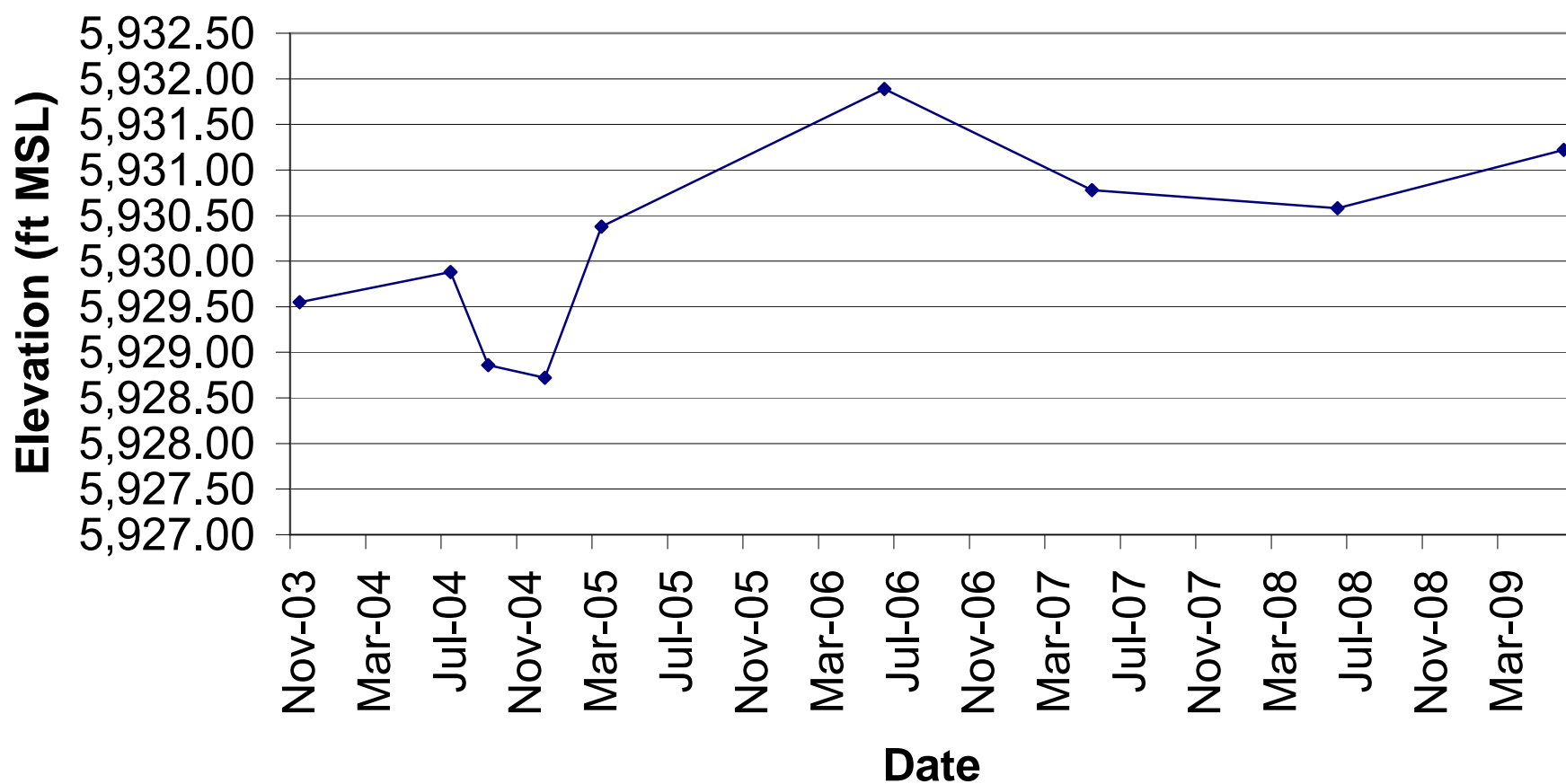
## Total Vanadium Concentration Trend



**Figure 5**  
**Nitrate + Nitrite Concentration Trend**

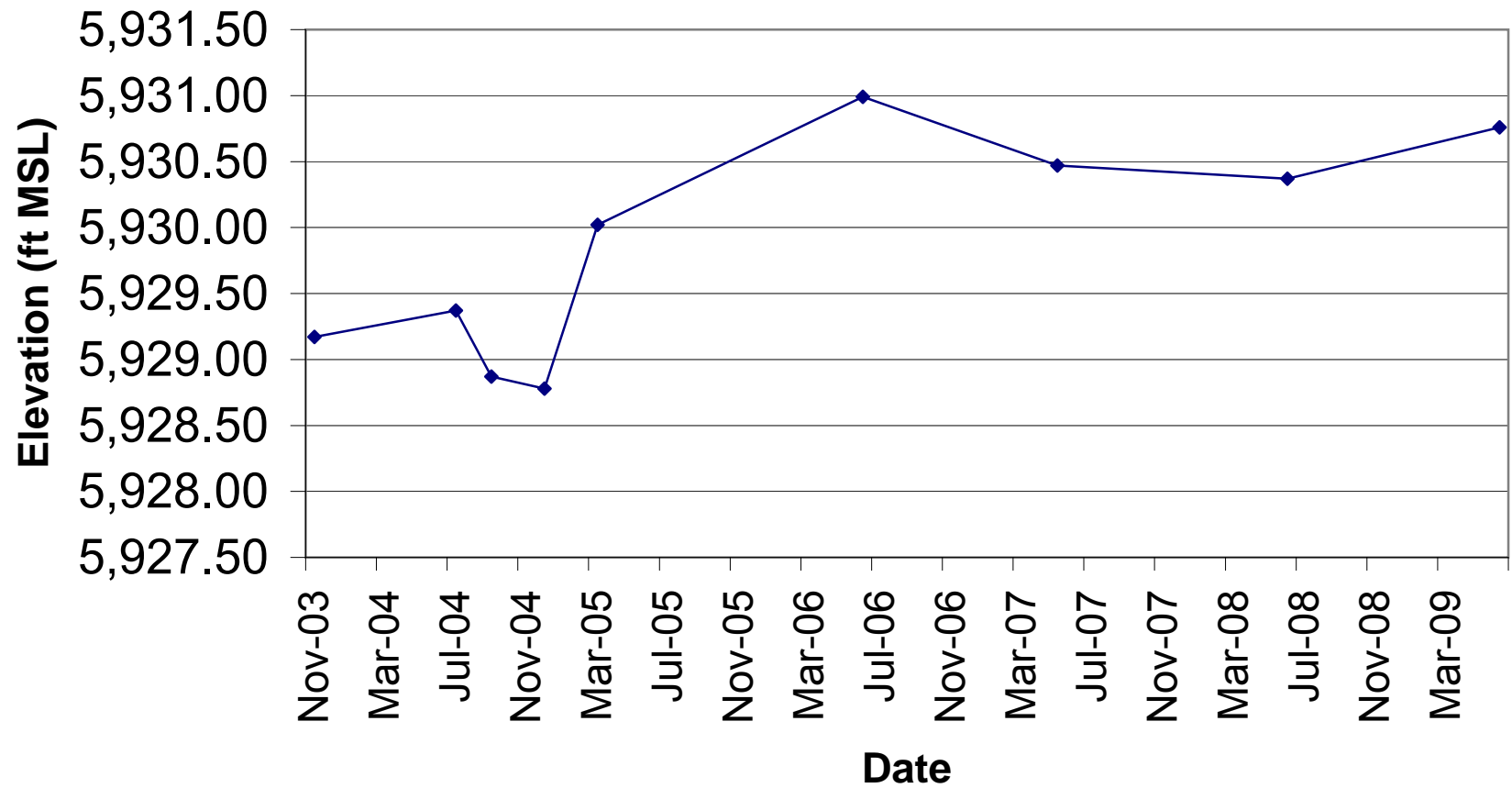


**Figure 6**  
**EV-1 Ground Water Elevation**

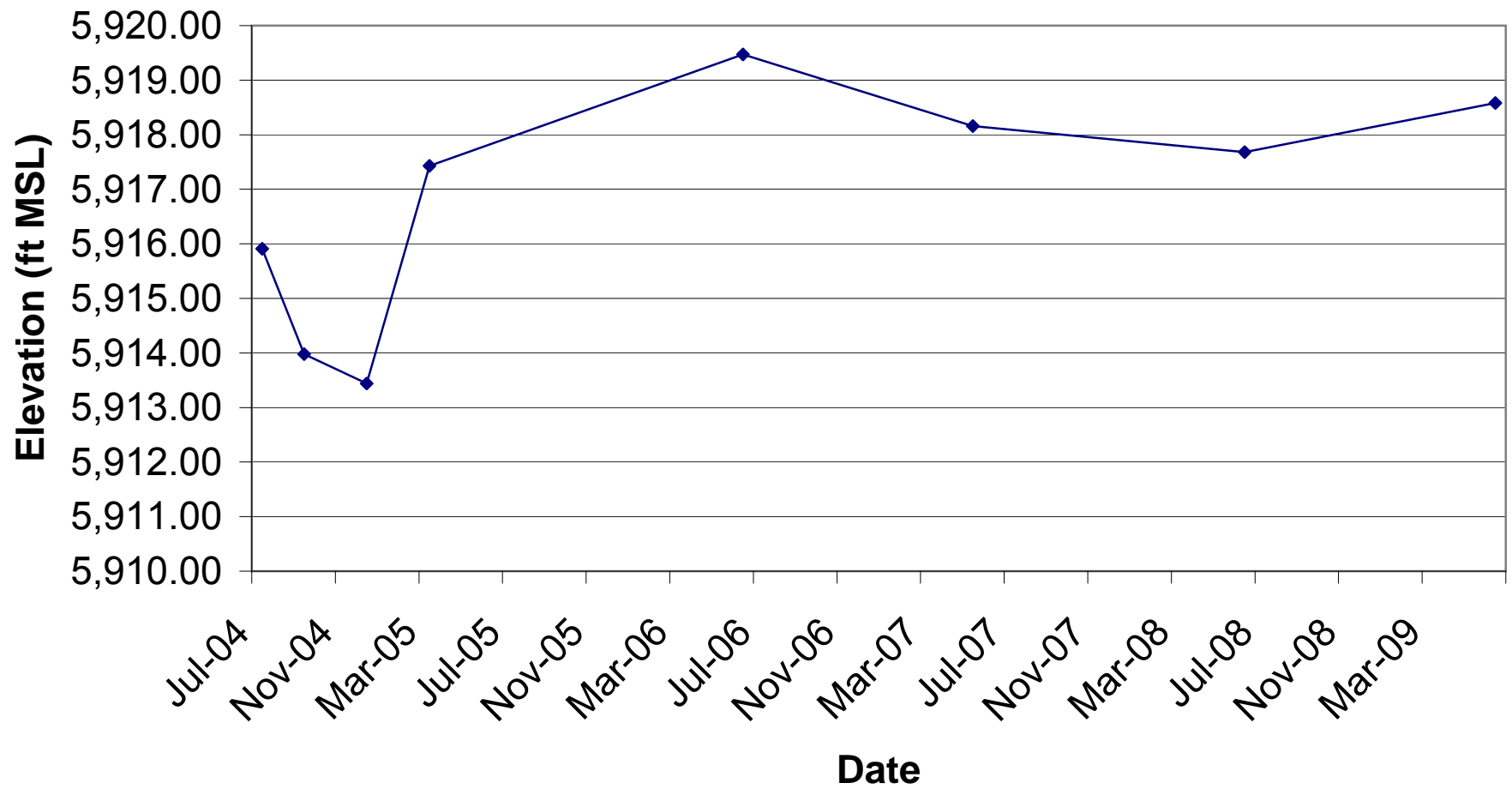




**Figure 7**  
**EV-2 Ground Water Elevation**



**Figure 8**  
**EV-3 Ground Water Elevation**



**Figure 9**  
**EV-4 Ground Water Elevation**

